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# QRPp

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## Table of Contents

**From the Editor** . . . . . 2
Doug Hendricks, KI6DS
**QRP Operating News** . . . . . 3
Richard Fisher, KI6SN
**Some Disconnected (but Still Useful) Thoughts about Amateur Radio Antenna Systems** . . . . . 7
James Duffey, KK6MC/5
**The St. Louis Paddle** . . . . . 16
Dave Gauding, NF0R & Andy Becker, W0NVM
**Test Equipment That Doesn't Cost a Mint**
**An RF Probe** . . . . . 26
Graham Firth, G3MFJ
**Test Equipment That Doesn't Cost a Mint**
**A Simple and Inexpensive Audio Signal Source** . . . . . 27
Tony Fishpool, G4WIF
**K20 CW/Keyboard Keyer** . . . . . 29
Steve Elliot, K1EL
**The Rochdale Mini QRP Convention 2000** . . . . . 37
Dick Pascoe, G0BPS
**QRP to the Field 2000** . . . . . 40
Jan Medley, N0QT
**The Epiphyte 3, A 75 Meter SSB Transceiver** . . . . . 47
Derry Spittle, VE7QK
**SMK-1, Rock Bound No More** . . . . . 59
Wayne McFee, NB6M

### From the Editor

Doug Hendricks, KI6DS

Holiday greetings to all of you. This is another good issue of QRPp with lots of projects to build. We have several familiar authors, and a new one, Steve Elliott, K1EL You will also note that the format of QRPp has changed a little. We have gone to one column, which will make the articles easier to read. Graham Firth, G3MFJ made the suggestion. Speaking of Graham, I am pleased to announce a new QRPp feature column, Test Equipment That Doesn't Cost a Mint. Graham and Tony Fishpool, G4WIF gave a wonderful presentation on that subject at Pacificon 2000, and we have decided to make it a regular column for QRPp. Each issue will feature a simple piece of test gear that you can build for your shack. Hopefully you will learn as you build. With that, on to the issue. Enjoy, Doug, KI6DS

## QRP Operating News

By Richard Fisher, KI6SN
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**That warm QRP glow**

**Bruce Hopkins, KL7H,** writes from the Bahamas that he "just had to tell you about a simple QSO that I had on 40 meters recently.

Central Bahamas to New York with 2 watts! No big deal, right? But wait, there's more.

Mike Branca, W3IRZ, kitted a limited number of transmitter kits for the North Georgia QRP Club called the NoGa-80. I was very fortunate to be able to get one. Mike was only able to make a few kits because most of the parts came out of peoples junque boxes, you see, this is a two tube 2 watt transmitter. It uses a 12V wallwart for the filaments, and rectifies and filters the 115-volts AC house voltage to come up with 150-volts DC for the B+. Mike says just about any audio or transmitting pentode will work with perhaps a few small parts adjustments. My rig uses two "Mighty 6AR5" firebottles in parallel to deliver approximately 2 watts to the antenna.

A simple mod to the coil turned my rig into a two-bander, 80/40. I built it on a small cedar box that some Alaskan smoked salmon came in. Mike's original version was built in an Altoids tin with the power supply in a separate plastic container. This kind of project lends itself to creative packaging. I spent a couple of very happy days putting this little jewel together, and it has rekindled my glowbug juices. This is fun! If it sounds half as nice on the receive end as it does in my monitor receiver, I am pleased.

Now to put that 80/40 regen receiver together. Where's my kerosene lamp? I will be on most evenings between 9 p.m. and 11 p.m. Eastern time zone. My main operating frequencies will be 7.040 or 7.050 and 3.579. Mike has been kind enough to let me reproduce this circuit on my webpage so others might enjoy this rig. I will also put up the circuit for his nifty 12V two tube regen receiver that might make a good mate.

I have not built the receiver yet but once parts arrive on the mailboat, I will be giving it a try. If you have any leanings toward "hollow state," this is fun! Just remember, that you will be dealing with possibly "Lethal Voltages", so if you are not competent with this, do find an Elmer that is to keep you safe! The web page should be up by the time you read this. Look under GlowBug on my site below. "Keep-em-Glowing."
(The KL7H website is: http://www.qsl.net/kl7h)

**Milliwatting the SP**

**Randy Foltz, K7TQ,** writes from Moscow, ID that he "worked the October Spartan Sprint at 100 mW with a K2 and a GAP Titan antenna. From here in ID I made only 6 contacts, but they were worth it! The farthest was

with Carter, N3AO, in PA for 21,090 miles per watt. Other 20 meter contacts were with Doc, K0EVZ, in ND for 7,660 miles per watt, Mert, W0UFO, in MN for 11,510 miles per watt, and Brian, K7RE, in AZ for 9,420 miles per watt.

Before the contest was over I made two 40 m contacts. One with Russ, AA7QU, for 3,230 mpw and one with Wes, W7ZOI, for 2,900 mpw. Each of these operators have great ears! At 100 mW you don't work everyone you hear. It seemed that stations on the edges of the activity had better success. Tonight increased my state total to 8 with 2 provinces since the first of September using the GAP and 100 mW. Over the weekend I worked JE1REU on 10 m for 50,200 miles per watt. He gave me a 559, but maybe he was just generous. At least I didn't have to repeat things. It doesn't take beams on tall towers to work a few with 100 mW. (But it helps!)

**A charged-up QRPer**

**Jim Hale, KJ5TF,** writes that "the last couple years I had a blast island hopping in Arkansas.

Yes! We have islands on lakes and rivers. In activating 3 of them for the US/VE Islands Awards program, I've had some fun carting batteries around. I found that for a short afternoon of CQ'ing on the beach at 750mW I could take one 13v nicad battery pack along and that was enough. If I thought 2w was going to be needed, I'd take a second battery pack. I found some surplus 2AH "C" cell nicads, and re-soldered the 10 cells to a pack. Using a wire stinger on a Black Widow 20ft pole, with 2 raised radials on 20M I had no problem making contacts all afternoon. Many of the contacts went into "QRP Limbo" as I lowered my power to double digit mW's, working state after state.

If a person is camping or hiking and wants to take a solar panel along, that's great. Those roll up kinds are pricey. I'd look at those dash board solar battery chargers. I've seen them in JC Whitney, and other places on special around $20. It's been years though. Sure they are not 5w, but even a fraction of an amp can re-charge some 2AH "C" cell batteries in time. You could look for the hottest charger of that type, and buy two when they go on special. If you've never tried mW'ing while portable, or mobile I can tell you it really works!

When the 49er rigs first came out, I used to take my 250mW 40M 49er mobile with me. I could make several contacts in evenings with a 40M Hamstick! You could also use a QRP rig that works ok on less than 12v. The 49er ran fine on a 9v btry. One of those dashboard solar chargers might charge up 9v worth of "C" cell nicads FB! I have some pictures of my Slate Gap island expedition on my webpage if you'd like to look, please do."

**QRP fun on 'Friday the 13th'**

**Paul Christensen, W9AC,** writes from Jacksonville, FL that on a weekend in mid-October he "began planning for a short camping trip with my two daughters. Since they both like Goldhead State Park near Gainesville, FL, we decided to travel from our home in Jacksonville to the camp site late yesterday morning.

After pitching our small three-man tent I immediately began assembling my W6MMA/St, Louis Vertical. I carry enough No. 22 AWG wire to place anywhere from six to ten radials along the ground. The vertical was placed far enough away from the camp site and blended in nicely with the pine trees. I tuned the vertical for 40-meter CW using an Autek Research analyzer and completed the job in less than five minutes.

Everything was going along fine until I began critically listening with my Red Hot 40 transceiver. Every station sounded as if it was drifting and had PLL problems. Next, I tried my Norcal Sierra and Norcal 40A. Not nearly as bad, but when I keyed the Norcal 40A, my sidetone audio sounded raspy. Could it be my power source? Sure enough, my trusted 2AH gell-cell had gone soft after four years. Measured terminal voltage after charging was only 11 volts and was sagging fast. After all, it was Friday the Thirteenth and the moon was full!

Without another portable power source, I remembered that my Plymouth van had a 12-volt outlet at the rear of the van. Yes, another automobile that requires that the ignition switch be turned in the 'accessory' position in order to deliver power to the jack. All I can figure is that at some point in the past 10 years, a products - liability action commenced, an auto manufacturer lost the case, and now the rest of us have to live with this wonderful inconvenience, or make the change to the cars ourselves.

Anyway, I then plugged the Red Hot 40 into the van lighter jack, keyed the rig and I was finally on the air. But something was still amiss - the RH40 was nearly deaf on 40-meters. I need to investigate why.

After switching to the Norcals, the band was full of stateside and DX signals. The Norcal 40A still amazed me even though it's almost five years old.

I now own six QRP transceivers, including one completely homebrew, and the Norcal 40A is without a doubt my favorite to operate. The audio fidelity is great, I added the ABX filter, 10-turn pot, KC-1 and brought out all controls to the front panel.

I am anxiously awaiting the K1 from Elecraft, because the Norcal-40A for 40-meter QRP operation is about as Zen as it gets! I sure hope the K1 has the QSK speed of the SST!

About 9 p.m., I called F5PLC, and had a great ragchew QSO with him running only 2-watts into the W6MMA/SLV. He was absolutely floored that I was running this camp site setup and engaging in a transatlantic QSO with him with only a couple watts into a portable antenna on 40-meters. This is the stuff that makes this stuff all worthwhile!

I just finished putting all the camping gear back into the closet and

began preparing the shop bench for the Elecraft K1 kit! I'm sure it's gonna' be another winner!

**QRP Sweepstakes success**

**Gary Phillips, KA9NZI,** writes from Marengo, IL that while he's "certainly not a top-notch contester, I felt pretty good about my November Sweepstakes 2000 results until I saw some of the others being posted (on QRP-L).

My excuses: I've avoided the high profile contests for years, scared off by QRM and the machine-gun code speeds I set these goals for myself:

Operate at least 10 hours, which is more than I would probably have done as a non-bull. Spend at least 15 minutes of each hour calling CQ.

As long as I was doing that, keep it up until I broke the 100 QSO mark and could get the pin.

Fill in my missing states for this QTH: AK, ND, DE, RI, SC, and NY. (NY? Yep, no I don't know why.)

Within that framework, I guess I did OK. Achieved the first two, and I did get AK and NY 2-way QRP.

Here are the summarized statistics: Running a TS450S cranked back to 4 watts out, G5RV antenna at a nominal 40 feet (but it passes through a maple tree.)

**Total hours:** 13
**Total QSOs:** 110
**Sections:** 42
**Score:** 9240 (if they don't throw some out for bad copy).

I did call CQ much more than I normally would, but with few takers. . . . QRP stations in my log were as follows: VE6BIR/7, KL7AC, K6MI, W0AH, KI0II, K7ED, K6EIL, K7QO, K7RI, K5NZ, W2EB, K0FRP."

# Some Disconnected (but Still Useful) Thoughts about Amateur Radio Antenna Systems

by James R. Duffey, KK6MC/5
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I have been a ham for more than 30 years. Antennas have always been a passion for me. There are few areas in the typical amateur radio installation that can offer so much improvement to overall station performance than attention to the antenna system can provide. I am a firm believer in home-brew antennas. They are far less expensive than the commercial variety and can be built with better performance. Contacts made with a homemade antenna offer a high degree of satisfaction and build confidence in one's technical ability. When I say antenna system I am referring to more than just the antenna, but rather the antenna, feed line, any tuner that is required and any balun matching device.

**What can I Do to Improve My Antenna Performance**?

There are some things that can be done to improve antenna performance. If you can't trade that old ground mounted trap vertical for a 5-element monobander at 100 feet, you can still improve your signal. Consider the following:

**Raise your antenna**

Both verticals and dipoles will improve significantly with a gain in height. This is particularly true in urban areas where a low antenna can interact with a great deal of conducting material that can degrade its performance. While a half wavelength is generally considered the minimum height for an effective DX antenna, even increasing the height 5 to 10 feet can make a marked improvement in many cases. Raising a vertical from ground level to roof level and providing 4 radials per band will make a big difference in performance.

**Get Rid of Feedline Radiation**

Feedline radiation can distort radiation patterns, change the antenna polarization vector, reduce the effective height of the antenna, and result in unnecessary losses. The most common cause of feedline radiation is a transition from a balanced antenna or feedline to an unbalanced feedline or antenna. Examples of such terminations include; a dipole fed with coaxial cable, a vertical fed with balanced feeder and the popular "j-pole" antenna (which makes the mistake twice!). The way to prevent this problem is to properly make the transition. The proper way to make the transition is with a balanced to unbalanced transformer, commonly called a balun.

An RF choke on the braid of coax will give the same results. An RF Choke or balun can be made simply by coiling the coaxial cable according to instructions given in both the Handbook and Antenna Book. Alternatively, a simple balun can be made by winding 10 to 12 turns of RG-58 on a ferrite core of low permeability. Sevick's book on baluns gives full details. Many hams use a W2DU balun that consists of the feedline threaded through a dozen or so ferrite beads. Since the beads must be high permeability the losses are generally higher with this type of balun, but it is perfectly acceptable at HF, particularly for QRP use.

There is an excellent reference to air wound coaxial choke baluns on the web at:

http://www.berkshire.net/~robbins/technote/airbalun.html

The simplest way to feed a dipole is with a balanced feeder and a tuner. This is a simple and effective antenna. When comparing feedlines the loss of the tuner must be included, which for resonant antennas brings the total loss roughly equal to that of a coax fed antenna. This antenna system can be used on all bands though, while the coaxial fed antenna will have significant losses on bands other than odd harmonics.

A vertical can also gain from an RF choke. If the feedline is an odd multiple of a wavelength long, the radials and the feedline can combine to form an antenna. Coiling the coax at the feed point according to the figures in the handbook should help this.

**Change the feedline to a lower loss feedline**

While buying premium feedline may seem expensive; it is probably one of the areas where a ham can get the best bang for his buck. A commonly accepted figure for "acceptable loss" is 1 dB. If one is willing to accept 1dB feedline loss in a typical 66 ft feedline run: then zip cord is acceptable at the broadcast band, RG-174 at 160 M, RG-58 to 20 M, 8X to 17M, RG-213 to 10 M, and ladder line to well past 30 MHz. To paraphrase Ev Dirksen: "a dB here and a dB there and pretty soon it starts to add up to big losses". If 0.5 dB is the criteria, then zip cord and RG-174 are out of the picture, RG-58 is good through 80 M, 8X to 40 M, RG 213 to 20 M, and of course the ladder line is still below 0.5 dB at 10 M. The difference in cost between 100 ft of RG-58 and RG-213 is $23, which seems like little to pay for a 0.5 dB gain, at least if one does not have the checkbook in hand. Buy good quality feedline; much of the cut-rate stuff sold for CBers is next to worthless. I am often asked if the coax used for local area networks can be used to feed antennas. The answer is yes. Be careful about "taps" which are sometimes used to make contacts to the cable, and beware that the jacket might discolor in the weather, but that will not effect electrical performance.

I have made my own balanced feeder and am of the opinion that is

more trouble than it is worth. The 450-Ohm ladder line is $15 to $20 per 100 feet and is well worth it in reducing frustration. I don't get nearly as many comments about my choice of insulator materials though.

**Improve your ground**

If you are using a vertical, increasing the number of radials will have the biggest impact on the performance. For ground mounted radials, the length need not be resonant. In general, the more radials you have the better off you will be. Length is of secondary importance, but the more radials you have, the longer they should be. A good rule of thumb is that the separation at the end of the radials should be 0.05 to 0.1 wavelengths. Try to buy copper wire surplus by the pound. The wire diameter doesn't make much difference. Rental of a power lawn edger helps a great deal.

**Use your dipole as a vertical at low bands**

A dipole on 160 M, 80 M, and 40 M often cannot be erected at effective heights, greater than a half wavelength, for DX. One way to turn these antennas into better low-angle radiators is to tie the feedline together and feed it as a vertical against a few radials. This gives you a simple top fed vertical.

**Can I use PVC for Antenna Insulators?**

Yes.

PVC is a mediocre, but still acceptable, dielectric. It has a low softening point though, so excessive losses can cause problems. Don't use PVC for coil forms in high loss, high current applications, but for QRP use they are perfectly acceptable as trap forms, coil forms, center insulators and end insulators. PVC was widely used in antenna applications through the late 70s without anybody questioning it. Even several commercial products used PVC. This is not surprising since PVC is probably one of the widest available antenna materials with every hardware store carrying it in one form or another. In the late 70s QST carried a picture of a coil that was wound on PVC that had melted. This started the hue and cry against PVC that still exists today. However, the coil was long, of small diameter, wound with small diameter wire, and used as a base-loading coil for a short 160 M antenna. The coil had excessive losses, which in turn lead to heating of the coil and form which lead to the meltdown. For most applications, PVC is perfectly acceptable. A recent Antenna Compendium carried an article on mobile antennas where the author found that a coil wound on PVC had a quality or Q factor only 10% less than a similar air wound coil.

I prefer the PVC sold as electrical conduit. It is gray in color and available in most building supply stores. It is UV resistant and is designed to stand up to the weather. Plumbing PVC is usually resistant to UV, but not always. One of the urban legends floating around the ham world is that one

can verify the effectiveness of a given PVC sample by nuking it in a microwave. While this is a fun experiment (along with microwaving raisins and frozen cockroaches), it will tell you little about the dielectric losses at HF. The dielectric constant can change significantly from 2.4 GHz to 7 MHz, and go either up or down. However, if it will make you sleep better at night go ahead and do it.

**Don't Use End Insulators**

Following a suggestion in Moxon, I have stopped using end insulators. I simply tie a sheet bend or double sheet bend (see a Boy Scout or Girl Scout Handbook for details) using the wire and support line. I use the smallest diameter line I can get away with to support the antenna. Depending on what the sporting goods store has in stock, this is usually 50 to 100 pound test nylon monofilament sold for fishing reels. This is not an optimum material for end ropes though. I have found at my altitude, 7000 ft ASL, it gradually looses strength and has about half the breaking strength after 3 years in the sun. My antennas seldom last more than 3 years, as I am off to try something new in shorter time than that. If my antenna comes down I consider that a sign that I should put up a new one!

**Add a Resistor across the Antenna Feed Point**

If the feed point is open such as in a dipole or vertical, consider adding a high value resistor across the feed point. For a low impedance antennas such as a dipole or vertical a 20 kOhm or higher resistor will do. For a high impedance antenna, use a 100 kOhm or higher resistor. This resistor is handy for evaluating feedline integrity; just put an Ohmmeter across the feed point in the shack. If it reads anything other than the resistor value, you have a feedline problem. The resistor also puts both sides of the antenna at DC ground, which can help eliminate precipitation static. The power dissipated in the resistor will be minimum if it is large (100 times or so) compared to the feedpoint impedance of the antenna.

**Don't Use Pulleys!**

I have stopped using pulleys to raise the ends of antennas on my masts. I use instead the ceramic insulators used by electricians to fasten the electrical drop wire to houses. These look like half eggs with a hole in them and a screw attached to the flattened end. I put the rope (called a halyard) through this hole and use it as a pulley. The wires coming into the house are much heavier than any wire antenna I have erected so I know it will hold. the finish is smooth so the rope slides freely. Best of all the thing can't jam, rust, or disintegrate in the sun. They too, are commonly available at building supply houses. While you are at it, install two pairs of halyards in case one breaks. Plan ahead.

**Buy a Heavy Duty Soldering Iron**

That 25 or 35 watt soldering iron you used to assemble the latest NorCal kit won't cut the mustard when trying to solder outside in the wind even on a warm summer day. Forget about it in the middle of winter with a cold north wind and temperatures in the teens. At least a 100-watt iron is needed for antenna work outside. Radio Shack sells one that is almost adequate; the old American Beauty Soldering irons sold to plumbers are much better if you can find one. Many people use soldering guns and they are widely available. I have always found the tips to be fussy and need tightening at the most inconvenient times. A very long extension cord is also very useful.

**Antenna Supplies for the Building Supply Store**

Your local Home depot, Builders Square, Lowe's, or local hardware store can provide you with many supplies useful for antennas. The cost may be higher than you would pay elsewhere, but when you come home on Friday evening and need to repair the antenna for Sweepstakes the next day, the convenience is worth the price. I have found the following items at hardware/building supply stores to be useful in my antenna work: wire (this is one case where the building supply store may be cheaper), ground rods, clamps for ground clamps, wire nuts, NoAlOx/Penetrox compound for joining aluminum tubing, electrical tape (get Scotch 33), liquid coat for taped joints, Teflon tape, plumbers strap (sometimes this is available in copper), electrical house drop insulators to use instead of pulleys (see above), pulleys (in case you didn't read above), PVC pipe and fittings, wood for masts, steel tubing for masts, a few selected sizes of aluminum tubing (usually very expensive), stainless steel hardware, U-Clamps, hose clamps, cable ties (get UV proof ones), solder, soldering irons, epoxy, silicone caulk, and telephone interference filters. I am sure that I have left some things out. Avoid the temptation to buy 300-Ohm twin lead or RG-59 TV coax at the building supply store. It usually is of poor quality. For emergency feedlines, Radio Shack is a better choice, but still not the best. Any port in a storm!

**Some Words About Antenna Tuners**

I acquired my first antenna tuner in 1965 as a novice, WN0MWN. My dad, now WA0OML, bought it for me after I got a "pink slip" from the Grand Island NE FCC monitoring station for radiating a second harmonic of my 80 M CW signal on 40 M. He had read that it might reduce harmonics. Properly tuning the grid would have been a better solution, but man is always enamored with technology. It was a Millen Transmatch Jr. I still have it. It is a thing of beauty. The wire is silver plated as is the inductor, the capacitors have ceramic endplates with velvety smooth double ball bearings, there is a heavy duty ceramic switch with silver plated contacts, and the chassis is heavy copper plated steel. It is most useful on coaxial fed antennas, although one must avoid the temptation to load up on a

band where feedline losses are high.

The Millen is a classical Transmatch Tee match. It is worthwhile obtaining one if you can. It is much the better tuner than any Tee match on the market today.

If you feed balanced feeders, the Johnson Matchbox and Matchbox Jr. from the same era are worth acquiring. They have similar construction to the Millen and are still very useful in a modern shack.

If you are purchasing a tuner new, the Z-Match is as good a QRP tuner as any. You can also home-brew one from plans in Antenna Compendium Vol.5.

Besides the Z-Match an "ell" match is a good home-brew project. With only two components, a capacitor and inductor, it has low losses and will match a wide range of loads.

**Keep Good Records**

Whenever I put up a new antenna, I always record the configuration and SWR (or impedance) plots in my logbook. I suggest you do the same. Then if you think you are having antenna trouble you can check the readings you have with the readings when the antenna is new. I also record the type of wire I use, and any other facts that seem pertinent at the time. This also gives you a good idea of whether or not your new antenna is performing up to snuff by comparing the QSOs before and after the new antenna is erected. Most hams will agree that newly erected antennas work best. The test of time is often not so kind.

**I Want to Build an Antenna, Which One Should I Build?**

The antenna books and magazines are full of antenna designs. It is sometimes difficult to choose. I offer the following suggestions. They are antennas that are simple to build, easy to get going with a minimum of test equipment, perform well and are easy to understand.

**HF Single Band**

Either a dipole erected as a flat top or inverted vee is the choice here. Cut it to the dimensions given in the handbook. Measure the SWR. If the SWR minimum is below where you want it, cut a bit off. If it is above where you want it, add a bit of wire. Don't worry about SWRs 2:1 or less. If you are compulsive or retentive don't worry about SWRs below 1.5:1. This antenna works best at heights above a half wavelength, but erected at any height and fed with low loss feedline it will reward you with lots of contacts. The inverted Vee is probably the easiest way to get height. Remember to use a coiled coaxial cable balun at the feed point.

**HF Multiple Bands**

For this use, I suggest parallel dipoles. Dipoles for harmonically related bands are fed from a common point. Interaction between dipoles can

be minimized by keeping the ends apart. Dropping the ends perpendicular to the antenna by a foot or more is usually effective. Again, use a coaxial cable choke at the feed point

**HF Vertical**

Single band verticals are more difficult to fabricate than dipoles. However, quarter wave verticals with multiple radials supported from a push up fiberglass mast such as the SD-20, Black Widow, or DK9 pole will work well. A coax choke will help here, as will lots of radials. This is a good candidate for a stealth antenna as it can be raised and lowered readily as needed.

**VHF Omnidirectional**

The coat hanger special can be built for less than $3 and will perform as well as any commercial antenna. It is a quarter wave ground plane. Buy a SO-239. Go to Radio Shack if you need to. Cut five lengths of 12-gauge wire to 19.5 inches. Solder one length to the center conductor of the connector. Solder the other four to the mounting holes. Droop them about 45 degrees. Feed with RG-213 or better. This can be mounted by taping the feedline next to the connector to a mast. You can use this indoors as well. Locate it in front of a window. This antenna will blow the pants off a rubber duck. I use THHN wire intended for house wiring. It will start to look a bit ragged if left outdoors for a while, but the performance will not be affected. It is easily replaced or straightened in any case.

**VHF/UHF Gain**

There are two choices here. The venerable Quagi antenna is a long boom (14 ft) that can be constructed from wood, copper wire and small diameter tubing. It has been a handbook mainstay for 20 years. The performance is not as good as more modern VHF Yagis that have been computer optimized, but it is within a dB or two of the optimum gain for its boom length. When built with reasonable care to dimensions they work without tuning. A balun at the feed point should be used. Either coiled coax or a W2DU style balun should work well here.

Kent Brittain has designed a number of Yagis that can be built with wood, copper wire and aluminum tubing. I have built several and they work quite well. The gain is within a dB of optimum for the boom length. No balun is needed as an unbalanced feed is used. These plans were recently published in CQ's VHF magazine and are also available on the web at:

http://www.clarc.org/Articles/uhf.htm

**Hams with One or More Home-brew Antennas Under Their Belt Might Want to Try One of These**

Loops (either vertical or horizontal)
Two element Yagis (wire or tubing)
Center fed Zepp
Optimized Yagis for VHF/UHF
Long Wires (Point them in the right direction)
Phased Vertical Arrays (Read the antenna book chapter on this first!)

**Antennas for the Beginner to Avoid**

I am sure that I will get some flack for this list, but here I go anyway. Those with opposing views can give a talk at next year's Pacificon. See Doug.

Doug may even have opposing views. Many hams have good experiences with the antennas below, but I think there are better choices for the beginner to try. If you must use one of these antennas, try them after you have erected several antennas.

**Off Center Fed Antennas, Windom or Otherwise**

These can have problems with feedline radiation. This can lead to noise, poor performance, unpredictable radiation patterns, and difficulties in measuring basic antenna parameters such as SWR.

**The G5RV (at least the version with coax feed)**

This is a popular antenna and performs well when used as intended. As a multiple band antenna it can have excessive feedline losses. It will seldom work on multiple bands without a tuner in which case you are better off with a center fed Zepp, that is a doublet with balanced feeder all the way to the tuner.

**The W8JK**

One of the first closely spaced beams, this antenna can perform well. However, it has a very low radiation resistance and unless carefully constructed it will have high losses. Even if carefully constructed it has small bandwidth and tuning can be critical.

**End Fed Random Length Wire**

When fed right these can be excellent performers. However, they often require special attention to eliminate RF in the shack and can be frustrating for the beginner to get going.

**Any Commercial Antenna**

Build your own. Learn. Enough said. OK?

**Some Good Antenna References**

In these days of rapidly expanding technical information available over the Internet, I still find comfort in my technical books. In reviewing the

various reflectors on the net, including QRP-L, I often run across questions that the asker could have answered with a quick reference to **The ARRL Handbook for Radio Amateurs** or to **The ARRL Antenna Book**. Therefore, I recommend that any amateur acquire these two references before pursuing others. You needn't purchase these books outright, although they are good value as far as technical references go. Most libraries have copies of the Handbook, and larger libraries have copies of the antenna book. If you can't find either of these at the local library, your librarian should be able to obtain either one through interlibrary loan. While you are doing this, tell the librarian that no modern library should be without these two references.

Antenna technology changes slowly. Therefore, used editions of either book are still useful. Look for used copies of either at hamfests. The handbook is published yearly, while the Antenna Book is updated occasionally. The current edition of the antenna book is 19. I think that some of the earlier editions of the Antenna Book have more information that is useful to the typical ham than the latest edition contains, but that is another issue.

After purchasing and thoroughly digesting the above two references I would recommend **HF Antennas for All Locations** by Moxon; published by the Radio Society of Great Britain. It is available from the ARRL in the United States. Moxon takes an unconventional approach to antennas and has information that is available no here else. I would caution against taking everything Moxon says at face value, but the book is very useful.

If you are technical in nature, I recommend **Antennas** by John Kraus, W8JK. This book is written for a Junior/Senior level course in antennas and uses calculus, but much of it is accessible to those with knowledge of High School Algebra. Kraus is a true pioneer in antennas and electromagnetics, both in the amateur and in professional areas. He was the first to realize the importance of closely spaced elements for gain, which resulted in the W8JK antenna; he invented the helix and corner reflector antennas as well.

I find the **Antenna Compendium** series, now in Volume 6, to be very useful and a gold mine of ideas. I have not seen Volume 6, but all of the volumes are still in print, including Volume 1 nearly 15 years after its introduction; a testament to the quality of any technical book.

If you are into the low bands, 160 M, 80 M, and 40 M, the antenna sections of **Low Band Dxing** by John deVoldere, ON4UN, is excellent reading.

A classic for vertical antenna enthusiasts is **The Amateur Radio Vertical Antenna Handbook** by Capt. Paul H. Lee USN (ret), N6PL. This book has been in and out of print since its introduction as a series of articles in CQ magazine in the mid 60s. Most of the information cannot be found elsewhere and Lee has an excellent discussion of the ground requirements for vertical antennas.

The subject of baluns is treated exhaustively in Jerry Sevick's **"Build-**

**ing and Using Baluns and Ununs - Practical Designs for the Experimenter"** published by CQ. Sevick is W2FMI and presents balun designs for almost every application.

The now defunct **Ham Radio** magazine reserved its May issue exclusively for antenna articles, and it published some gems in its 23 year life. If you see a stack of used Ham Radio magazines at a hamfest it is worth digging through them to find the May issues if you don't want to buy the whole lot (which you should).

An Internet resource as valuable as many of the books above is the web site of L. B. Cebick, W4RNL located at:

**http://www.cebik.com/**

The site is chock full of good antenna ideas. L. B. has particularly good articles there on vertical antennas and the grounds that they require. The page is also a must for anybody doing antenna modeling on a computer. L. B. has also been kind enough to put many of his antenna articles that first appeared in **Communications Quarterly, Low Down, Ten-Ten News, and The National Contest Journal** at the site. A must visit for those with Internet access.

**Closing Comments**

I hope that you find some of these disjointed ideas useful. I find antenna building one of the most rewarding aspects of the amateur radio hobby. It is a vast subject and I hope that I have helped you to think in new directions with some of these ideas.

## The St. Louis Paddle

**by Dave Gauding, NF0R**
**nf0r@slacc.com**
**&**
**Andy Becker, W0NVM**
**arb@bbs.galilei.com**

In early 2000, K0FF sent along a small collection of homebrew keys and paddles for show & tell at a monthly St. Louis QRP Society meeting. Now retired near historic Hannibal, Missouri, George Dowell's finely crafted projects are always well-received. One single-lever paddle was constructed inside a 1/4 inch stereo plug and quite distinctive. It caught everyone's attention immediately.

The creative design featured externally adjustable contacts but was still suitable for the rigors of portable or trailside operations. Aside from being slim and compact the most important characteristic was performance. It handled as good as it looked.

Unfortunately, old-time lever switches or relays with thin tempered leaves

are critical for duplicating K0FF's very special paddle. These days such devices are in short supply and it can be difficult finding a number of identical units for kitting purposes. Finally, shop tools and the ability to use them properly are required.

A comparable design based upon readily available components was the logical alternative. We started the project with a clean sheet of paper. Fellow SLQS members routinely tested and critiqued the prototypes at five consecutive monthly meetings. Now only simple hand tools and basic soldering technique are required to homebrew this accessory.

The St. Louis Paddle can be plugged into four different applications: separate keyer, custom mounting base, front panel of a transceiver, or a custom cable assembly serving a separate keyer or transceiver.

A special adjustment feature was inspired by NB6M. He had designed a single-lever paddle with a passive tensioning system which met our needs perfectly. That homebrew project is currently featured on NorCal's web page. KI6DS also adopted the innovation when he designed the Iambic Paddle/TiCK Keyer Kit for the Ft. Smith QRP Club.

Homebrewers can collect the few off-the-shelf parts needed for a paddle and build it easily from this article. Have fun and as always modifications and improvements are officially encouraged.

### Materials

1 ea. Switchcraft #260 or #267 - 1/4 inch stereo phone plug
1 ea. 1/4 inch stereo phone jack
1 ea. 3/64 inch diameter brass rod
1 ea. 1/64 inch x 1/4 inch inch brass sheet
2 ea. adhesive rubber feet
1 ea. cable assembly (see text)

### Tools

1 ea. fine cut needle files
1 ea. 5/64 to 5/32 inch drill bits (see text)
1 ea. tapered reamer
1 ea. small soldering iron
1 ea small bench vise (see text)
1 ea. third-hand device
1 ea. heavy-duty wire cutters
1 ea. needle-nose pliers (see text)
1 ea. hobby knife

**Construction**

1. Using the heavy-duty wire cutters trim the plug's ground lug to an overall length of 15/16 inch. Take lug and completed sub-assembly measurements from where the plug's barrel connects to the threaded base. Cut the protective nylon shield from the ground lug with the hobby knife and discard.

2. Trim the tip lug and ring lug to an overall length of 3/4 inch. File all cut edges smooth. A threaded hole or soldering hole in the tip lug should be filed flat to aid fitting of the contact arm.

3. Trim two 1-3/16 inch contact arms from 3/64 inch brass rod. Square the ends and file cut edges smooth.

4. Trim one 1-1/2 inch paddle lever from 1/64 x 1/4 inch brass sheet. Square the ends and file the cut edges smooth.

5. Using the 5/64 inch drill start a tensioning hole centered 7/16 inch from the end of the paddle lever. Open the hole to 5/32 inch in the thin brass with progressively larger drills or a tapered reamer. Round off the corners slightly on the end that will hold the fingerpiece.

6. Now use the small bench vise to position the plug horizontally with the prepared terminals projecting from the jaws. The height of the plug should match the height of the third-hand. It will hold the contact arms and paddle lever in position for soldering.

7. Position the paddle lever in an alligator clip on the third-hand. Locate the part so the inner edge of the tensioning hole is immediately above the outer end of the ground lug. The operating end of the lever will then be 2-1/8 inches from the base. Adjust so the lever is perfectly horizontal, vertical and centered when contacting the ground lug. Solder the lever.

8. Following the instructions in paragraph 7, solder the contact arms to their respective lugs. The arm should project 1 inch past the end of the tip or ring terminal lug. After installation the operating ends will be located 1-11/16 inches from the plug's base.

9. Confirm that the contacts and paddle lever clear the shell and then remove it. Now install the rubber feet on either side of the paddle lever to create the fingerpiece. Press together tightly after insuring their placement will not interfere with the shell or contacts. Re-install the shell after the following adjustments are completed.

**Paddle Adjustments**

Using the needle nose pliers bend the tip of the contact arms inwards 45 degrees. Adjust so each tip is the same distance away from the lever. The actual travel between the arm and contact is a builder preference. This bending process is a coarse adjustment. Here are three fine adjustments:

1. Adjust the contact sub-assemblies by bending them at the soldered lugs using the needle-nose pliers.

2. Alternate the dot-dash polarity to dete[illegible] best fe[illegible]. Each

contact arm will be somewhat different because of the way the plug's tip and ring solder lugs are constructed.

3. Slide a one-quarter inch by 3/16 inch diameter heatshrink tube over the lever arm lug, contact arms and the tensioning hole. This addition can set contacts very close and will tighten the action slightly. Shrink the material incrementally with the heat from a soldering iron and test continually for best feel. Then file a small triangular notch in the top of the lever arm at the edge of the heatshrink to serve as a stop. It will prevent the tubing from sliding forward in use.

Lever resistance can be lightened while construction is taking place or done later after the builder has a chance to try the standard paddle. Here are three lever adjustments:

1. Enlarge the tensioning hole slightly with the tapered reamer or a larger drill. The lever will have to be unsoldered to accomplish this.

2. Lengthen the tensioning hole by filing towards the fingerpiece with a round file or by drilling another hole adjacent to it. Again, the lever will have to be unsoldered.

3. File a very shallow lightening notch in the lever above and/or below the tensioning hole. A round needle file is recommended for this work.

As designed, the St. Louis Paddle requires a fairly light touch on the fingerpiece. Builders desiring a heavier feel or less lateral flex in the mechanism can increase the diameter of the contact arms to 5/64 inch. The tensioning hole may be made smaller or even omitted.

**Builder's Notes**

The Switchcraft #260 or #267 stereo plugs feature heavy-duty screw or solder terminals as opposed to semi-flexible stamped metal terminals. The rigidity provided by the thicker lugs is required for this project. The plugs are available from Mouser as P/N 502-260 or P/N 502-267 and average $5.00 in single units. There is no Radio Shack equivalent. However, this part and similar plugs are common finds at hamfests at significant savings.

When substituting plugs the lever and contact arm dimensions may have to be adjusted. Those plugs should also feature insulation between the electrically isolated base sections designed to withstand prolonged soldering temperatures, i.e. not plastic.

The recommended soldering technique rotates a lug to the six o'clock position. Align the part to be added with the third-hand device and then apply heat to the bottom of the lug. Now apply solder to the joint between the lug and the part. Use only enough solder to make a serviceable joint. Excess solder tends to bend thin metal parts out of line as it cools and shrinks.

Inexpensive solid brass rod and sheet brass in 12 inch lengths is available in counter displays in most hobby shops. This is sufficient material for many paddles at an average cost of .50 per length.

A third-hand device fitted with alligator clips in multiple universal joints is a must for locating the components for soldering. Position the clip horizontally for the paddle lever. Position the clip vertically for the contact arms. The plug itself can be held in the pages of a thick book if a small bench vise is not available.

Small needle-nose pliers work well but small straight-nose internal pliers (with smooth, cone-shaped jaws) are preferable for turning the ends of the contact arms inwards. The lever and contact adjustments are truly a trial-and-error process but quite reliable in use.

**Cable Assembly Options**

A St. Louis Paddle plugged into a custom cable assembly allows the operator to send code some distance away from the rig or external keyer. A nearby flat surface for positioning a traditional paddle with weighted-base is not required. 24 or 30 inch cables are manageable lengths but builder preference applies. Here are two examples:

1. Paddle-on-a-Stick: Plug the paddle into a 1/4 inch in-line stereo jack which in turn serves as a handle. The Radio Shack 274-141C is readily available, low-profile and very lightweight. This system is appropriate for either two-handed or one-handed keying and definitely "trail friendly". After construction a tie-wrap strain relief should be added inside the plug.

2. Paddle-in-a-Bottle: This configuration uses a plastic pill bottle (1-5/16 inch diameter -16 dram typical) for a larger handle. It is fitted with a mating jack and intended for two-handed keying. For desk-top applications a matching lid should be fitted on the opposite end of the bottle. This addition keeps the pill bottle/paddle holder level when held down on a flat surface. Add a tie-wrap strain-relief to the cable.

Terminate the cable assemblies with 1/8 inch or 1/4 inch stereo plugs to mate with common keying jacks in commercial and kit equipment. 90 degree angle plugs are worth considering for rear panel insertion. Adapter plugs allow quick switching between sizes.

A high-flex shielded wire bundle is recommended for the cable assemblies. Re-cycled computer mouse cables are also suitable. Three conductors of computer ribbon cable are an inexpensive alternative for low-power equipment. When building multiple cable assemblies insure paddle polarity is identical for each unit.

**Design Notes**

The St. Louis Paddle was designed primarily for portable or mobile use. The project offers operating conveniences in these locations while minimizing the damage potential for more fragile keying devices.

The size and placement of the tensioning hole in the lever arm provides efficient keying action while preserving structural integrity. The tactile expectations of the operator are met with slightly extended lever travel. It is a fact-of-life with such a simple mechanism.

The contact arms provide a slight "click" when keyed and thus some audible feedback to the user in quiet settings. Having the contacts and lever meet at the operating end helps control contact bounce and lever over-travel at higher keying speeds.

The adhesive used for most rubber cabinet feet increases in strength several times when two of the parts come in contact. The characteristic is used to good advantage for this project as no permanent adhesive or mechanical fasteners are required for the small fingerpieces.

Removing installed fingerpieces requires care but is not difficult. The correct procedure is to grasp them between thumb and forefinger and gently roll both off the end of the lever at the same time. The adhesive will survive many removals and replacements. The pads should not be allowed to come in full contact with each other after removal. A thumb-nail or knife blade forced between parts may then be required for separation.

In addition to a front-panel location, the paddle can be operated by inserting it into a keying jack installed on the rear panel of a rig. Instead of turning the rig around rest the hand on the top front of the cabinet and reach back to grasp the fingerpiece. This procedure is an option when encountering a faulty cable assembly in the field or discovering it was left behind.

In the tradition of learning to use a bug or paddle, one-handed keying (with either hand) requires practice to develop the skill. Once mastered it is a welcome operating convenience for contesting or mobile. Pressing the base of a hand-held in-line plug assembly on a desk-top or thigh provides stability and aids the learning process.

**Customizing**

The position of the dot/dash sides can be identified in several ways for day or night operating. One method includes sandwiching rubber feet of different shapes, sizes or colors to create a distinctive fingerpiece. Colored or reflective tape, a notch or raised indicating surface added to the plug's shell are also effective.

Choosing half-round rubber feet provides a wider range of actuating angles for the fingerpiece. This is may be helpful to some users and particularly during one-handed operation. A common 7/16 inch diameter pad is a good starting size.

Solid steel or brass bar stock can be used to construct a desk-top base for a paddle. Select a size, weight and height compatible with personal keying styles. Drill or mill the stock to accept a mating jack. Finish with a non-skid base and the connecting cable.

**Performance Issues**

The completed paddle is just about "bulletproof" unless the protruding brass lever is bent from a sharp blow. Even then damage may be field repairable with hand tools. All soldered joints and the contact arms are

protected inside the plug's plastic shell. Given the modest expense, adding a spare unit to the field kit is a sensible precaution.

The standard single-lever design sends code comfortably well into the 30 WPM range. The difference in feel between hand-held keying and keying from fixed equipment is noticeable. With this in mind builders may wish to tailor a paddle for a specific application.

An ergonomically friendly version of the St. Louis Paddle dedicated to one-hand operation is being discussed. A leg-mounted paddle accessory is in the design stage. An iambic prototype with adjustable contacts is under test.

**Conclusion**

A St. Louis Paddle may be used at the operating desk, portable or mobile. Equipped with a cable assembly it offers alternatives to traditional desk-top code-sending systems. This is an inexpensive and easily homebrewed accessory that performs well.

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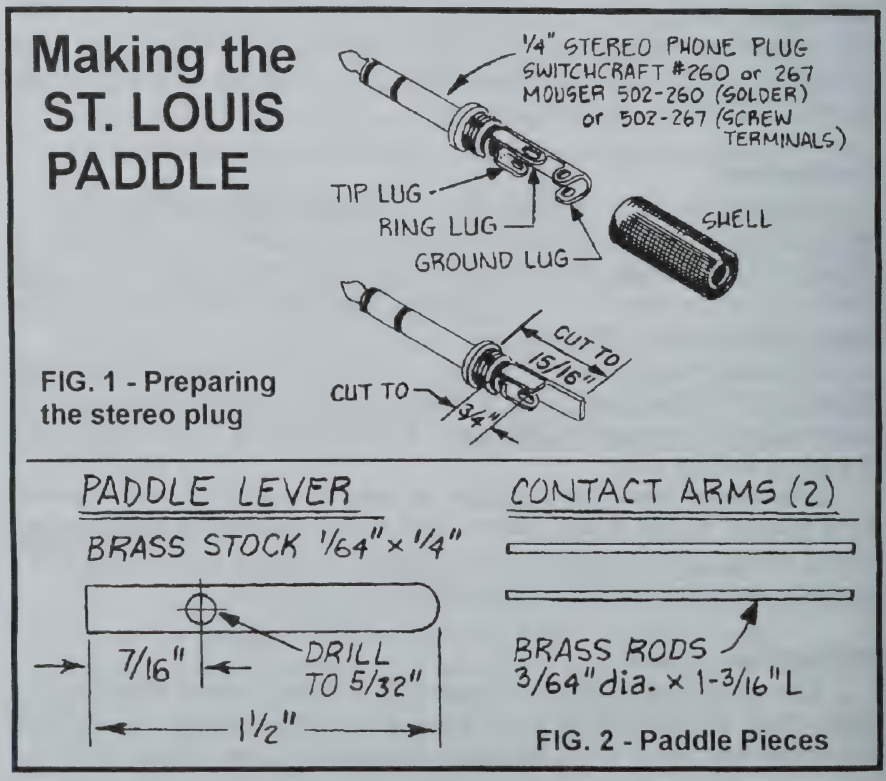



**FIG. 1 - Preparing the stereo plug**

**FIG. 2 - Paddle Pieces**

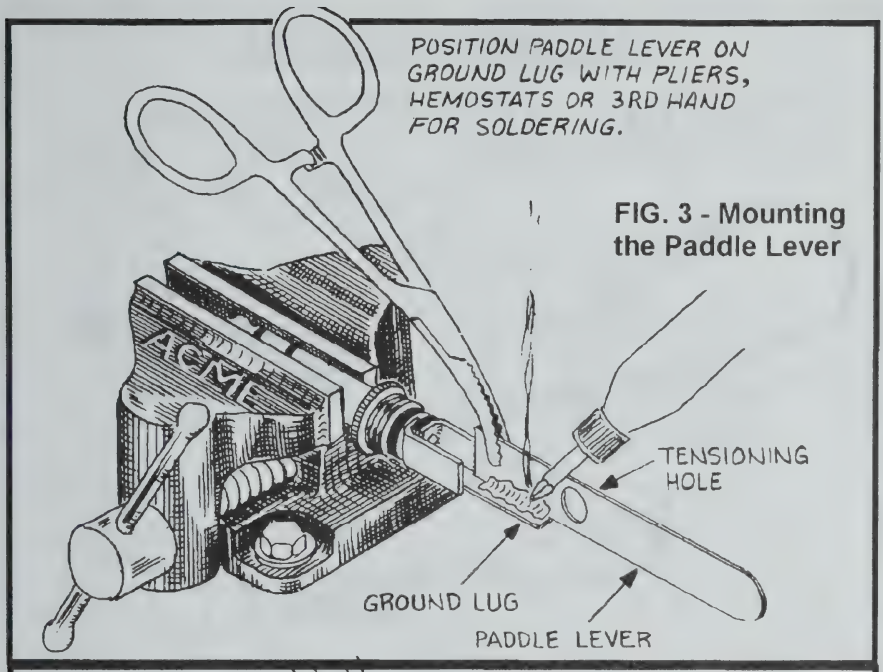

POSITION PADDLE LEVER ON GROUND LUG WITH PLIERS, HEMOSTATS OR 3RD HAND FOR SOLDERING.
ACME
TENSIONING HOLE
GROUND LUG
PADDLE LEVER

**FIG. 3 - Mounting the Paddle Lever**

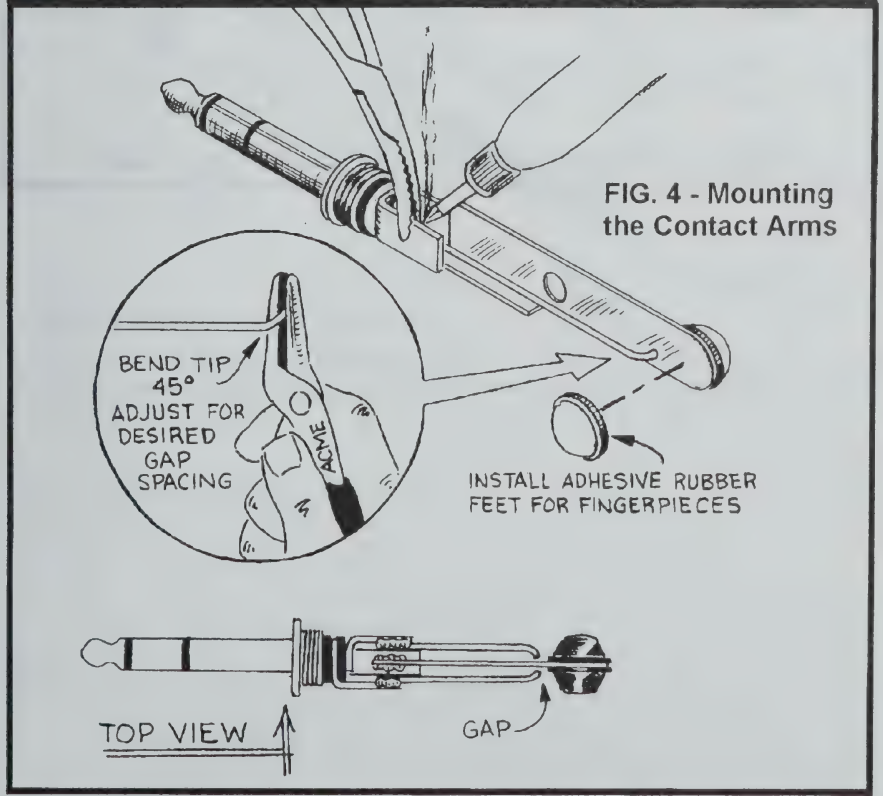



**FIG. 4 - Mounting the Contact Arms**

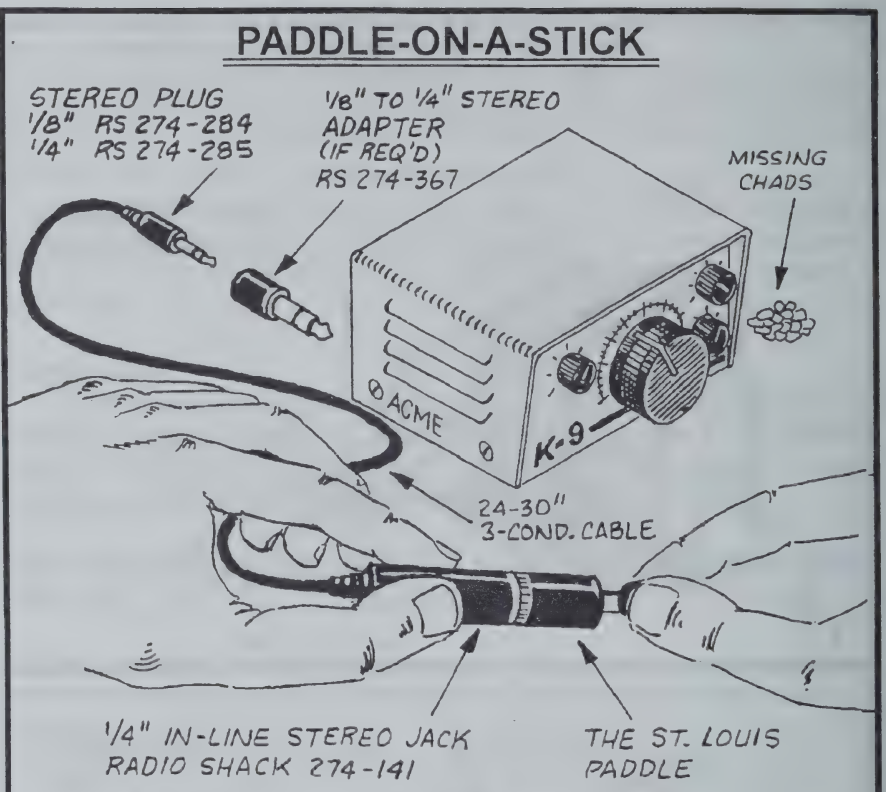



FIG. 5 - "Paddle-on-a-Stick" Construction and Usage

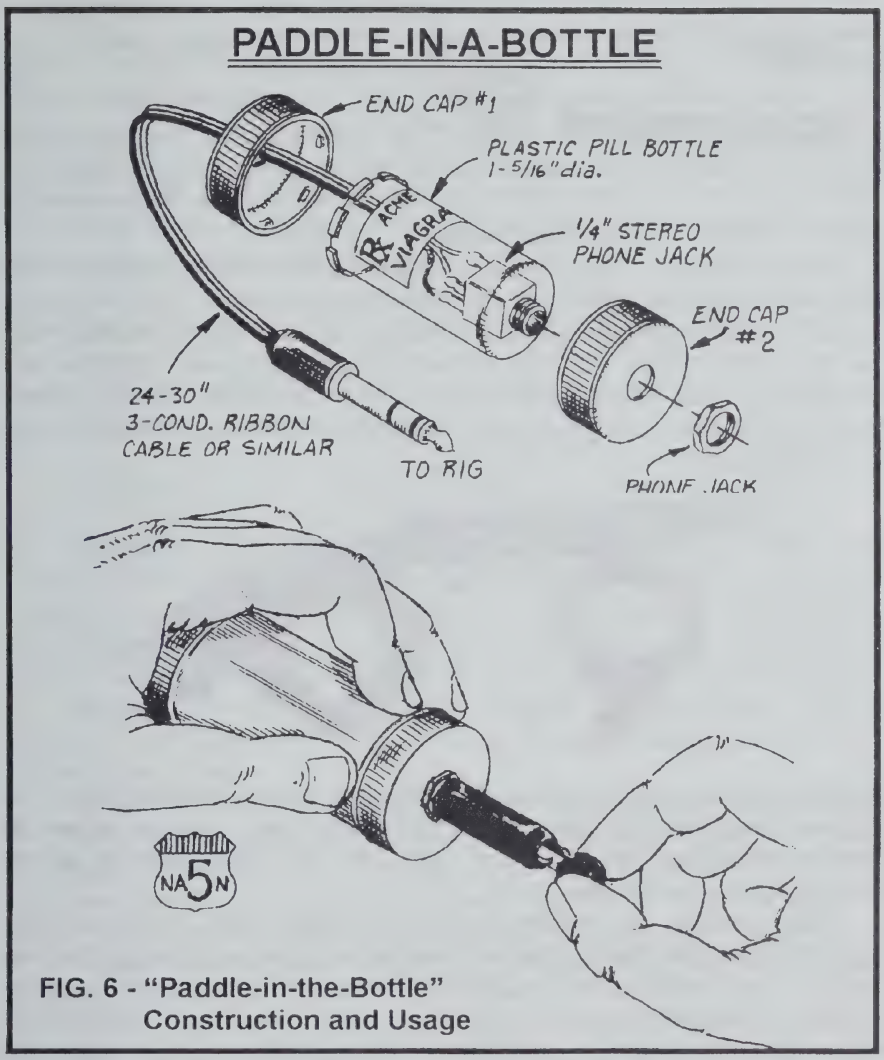



**FIG. 6 - "Paddle-in-the-Bottle" Construction and Usage**

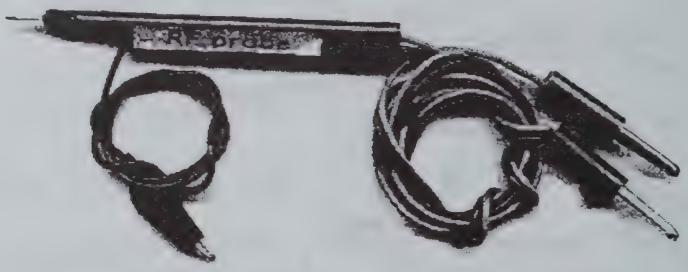
# Test equipment

That doesn't cost a mint!

By Graham Firth G3MFJ/W3MFJ

**Part 1 - An RF probe for your meter**

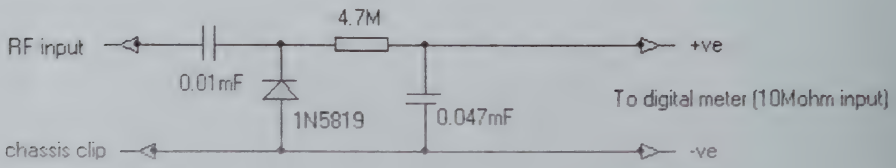
This is the first of a series of articles on simple test equipment. Test equipment does not have to be complicated to be useful. I cannot offer a circuit for a one-transistor spectrum analyzer, but you can do test to check the functions or any home-made equipment using such simple test equipment as this. This RF probe was one of the pieces of "Test Equipment that doesn't cost a mint" that Tony, G4WIF & I described at Pacificon late in October 2000.



It is a very simple circuit and is very effective in use. However, this does not stop people selling them at vastly inflated prices. I saw one at a local hamfest being sold for $70+ and I am sure that it will have an almost identical circuit to this one.

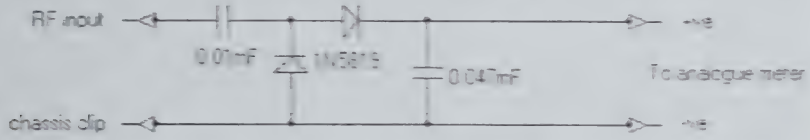
Two versions are shown here. First, if you own a normal, non-autoranging digital meter, this will have an input impedance of 10Mohm and the first circuit below will suit this. The second circuit is slightly different and is designed to suit an analogue meter. These are usually 20,000 ohms/volt and the circuit modifications give a higher output, which will give a better indication on these meters.

The circuit for a digital meter.



The two capacitors can be any type available, although if you intend to use the probe on voltages higher than 24 volts, the input 0.01 capacitor should able to withstand this. The diode specified is a Schottky diode. This was chosen as it operates well at HF, and it has a low voltage drop, thus making it more sensitive. Any equivalent diode will suffice. If a Schottky diode cannot be obtained, then I suggest a germanium, rather than a standard silicon diode. The value of the resistor is calculated so that the meter gives an approximate RMS reading.

Now, here is the circuit of the probe for an analogue meter.




The same comments as above apply for the capacitors. This time, to increase the voltage available, I have used two diodes to give a voltage doubler. Again I recommend Schottky types, but the comments above also apply to them. The output is uncalibrated because of the lower impedance of the test meter, the impedance of the source will affect the reading.

The case I used came full of 0.5mm leads for a refillable pencil. Whenever I get anything like this, I put it to one side just in case I can use it for some future project.

The RF probe can be used to detect an RF signal anywhere in a circuit, for example, to test whether a crystal is oscillating, or to check whether a frequency multiplier stage is giving an output. The absolute value that you read usually does not matter, however, some designers will give a value, or a range of values to expect and this may be used as a guide.

In future issues of this magazine, Tony and to describe other simple pieces of test equipment.

# Test equipment

That doesn't cost a mint!

By Tony Fishpool (G4WJF/N4WJF)

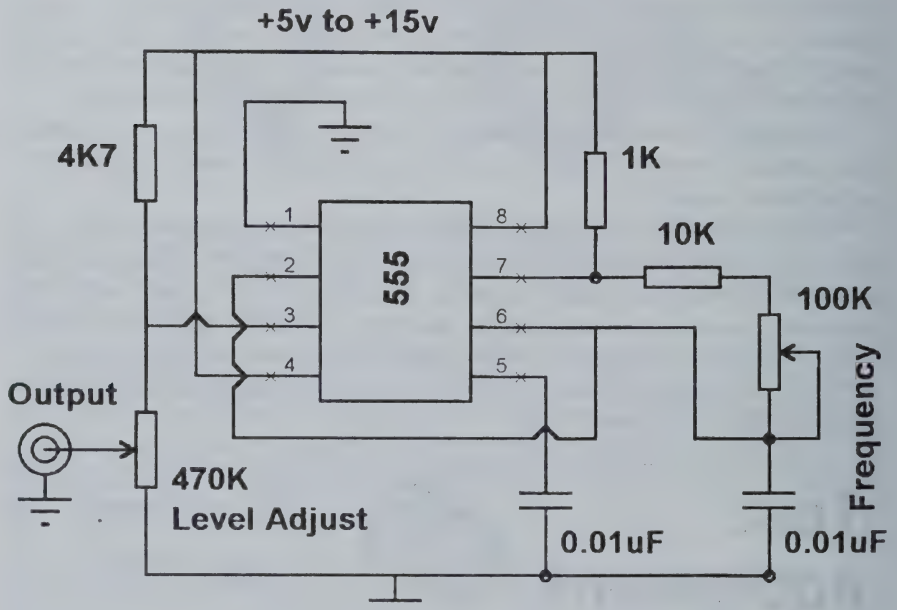
One of the most fun chips that has been available for years is the NE555 timer, they cost pennies, and you can use them for all kinds of things. In the September 1996 issue of QRPp, I used a double 555 (the NE556) as the heart of my Spectrum Wavemeter [1].

In this article, I have used a single 555 to provide a simple and inex-

pensive audio signal source.

If you have a suspect audio amplifier, you can fault find on it with a multi-meter (if you have an idea of what voltages should be present, and where) or either by replacing it with another (test) amplifier, or by injecting a tone and work your way back from the speaker where, hopefully, the signal will get louder, if it doesn't, you are well on the way to finding where the problem lies. This piece of test equipment could be made even simpler by having a fixed frequency, but it doesn't make it too complex to get it to cover approximately 650Hz to 7.2Hz. The output is square wave, but that doesn't matter for test purposes. In order to crudely control the level of signal to be injected, use whatever potentiometer you have in your junk box, and if they are really small, the whole thing including battery will fit in an Altoids tin.

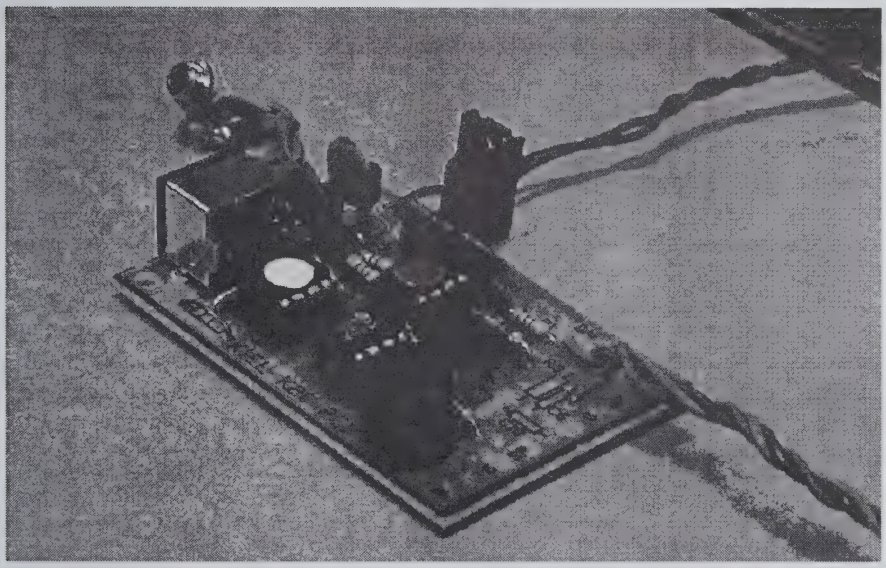
**Notes:** 1) In the September 1996 QRPp there was a mistake in the diagram of the Spectrum Wavemeter. In the circuit, the line between R6/R7, and C5/C6, are not joined and there wasn't an R11, even though it was listed!




**Schematic of Audio Signal Source by G4WIF**

# K20 CW Keyboard/Keyer

**By Steve Elliott**
**K1EL @ aol.com**
**8002445800**



Here's a fun little project that you can build in a couple of hours and have fun with right away. It's a combination CW keyer and keyboard that can key your QRP rig (or most any rig for that matter). It has many features to play with and is easy to build and use. A kit is available that includes all the board mounted components and a single sided PC board. This kit is suitable for a beginner or a club project since if it's built right it'll work, no alignment is necessary.

The intent of this article is to cover the development and architecture of the design. Detailed information about the features of the K20 can be found in the K20 User's Guide on my website: www.k1el.com In writing this article I hope to pass along some of the things I learned in the design process which might spark an idea or two in other hams.

**Design Requirements or "What makes a good CW keyboard design?"**

Here's where it starts, an organized list of what's essential:

A standard IBM keyboard interface with an on board PS/2 style connector.
Open collector Key and PTT outputs for connection to a transmitter or transceiver.
Sidetone that has both high and low level audio outputs.
Iambic paddle and straight key input.
Non volatile storage memory for messages, settings, and typeahead buffer.
LEDs to give the user feedback on operating mode and status.

All commands to be issued via the keyboard, no additional switches
On board voltage regulator able power keyer circuitry and a keyboard
RF filtering to prevent RFI and malfunction due to externally induced RF
Low power consumption and Small physical size
Easy to find components
Microcontroller with plenty of program space and I/O capability

**Easy Choices First**

The Microchip PIC was the microcontroller of choice due to its low cost, powerful feature set, and the availability of free development tools from the manufacturer. A two-kilobyte serial $I^2C$ EEPROM was selected for memory because it's nonvolatile and has a simple 2-wire interface. Nonvolatile means the memory retains its contents even when power is removed. This makes it ideal for storing messages and operational settings of the keyer. Instead of adding LEDs to the PC board, the Scroll Lock and Caps Lock lights on the keyboard will be utilized. For testing and convenience an on board peizo speaker for sidetone was a "must have".

**It all comes down to pin count and program space**

PICs in eight pin packages are a personal favorite since they don't take up much space and PC board layout is easier. On the other hand, a small package provides fewer I/O pins. Of the eight pins on a PIC 12C672, two are reserved for power leaving only six for I/O and one of those is input only. A nice feature of the '672 is its built in RC timebase oscillator eliminating the need for an external crystal or resonator. The RC oscillator suffers in absolute accuracy, but it's very stable and fine for a CW keyboard design.

This is a list of I/O pins required to implement the feature list:

| | | |
|---|---|---|
| PC Keyboard I/F | 2 | bi-directional |
| Transmitter Key | 1 | output |
| PTT | 1 | output |
| Audio Sidetone | 1 | output |
| Iambic Paddle | 2 | inputs |
| EEPROM I/F | 2 | bi-directional |
| Power & Ground | 2 | pins |
| **Grand Total of 12** | **pins** | |

That seemed to eliminate the 8-pin package. The next consideration was programming space. The PIC family incorporates program memory inside the part. Based on keyers I had designed in the past, the Morse generator, keyboard, EEPROM, and command modules would require at least three Kwords of program space. A PIC that would provide more than two kilowords of code space ***and*** provide enough I/O pins would be expensive and cost more than two PIC12C672s. Thinking along these lines, I

realized that two '672s could provide all the I/O needed and a total code space of four Kwords. I'd have the advantages of two small packages, low cost, plus internal RC oscillators. The trade off was that some of the I/O pins would have to be dedicated to support communication between the two PICs.

**Divide and Conquer**

How could the design be broken in two parts? A natural split emerged between Morse generation and keyboard interface. I could partition the design into a "Console" that would read the keyboard and manage the EEPROM, and a "Keyer" that would generate Morse and sidetone, monitor the iambic paddle and keep track of event timing. The Console would "talk" to the Keyer over a standard 1200-baud asynchronous serial interface, which would cost four I/O pins, two pins on each side for data and handshaking. I was almost there until I counted up the pins again, **RATS !** I was short one I/O pin . The 12C672 PICs have a built in analog to digital converter (unbelievable but true) and these are great for replacing multiple logic level inputs with a single analog input. With the resistor divider network shown in Fig. 1, two paddle inputs can be fed into a single A to D input pin. There are four paddle states: both paddles off, dit paddle pressed, dah paddle pressed, and both paddles pressed. Each state feeds a different voltage to the Keyer PIC. By converting this voltage to a digital value the PIC can determine the paddle state.

There is an interesting benefit derived from splitting the design. Since standard asynchronous 8 bit communication was chosen as the interface protocol between the Console and the Keyer, any 1200 baud asynchronous serial host can control the Keyer.

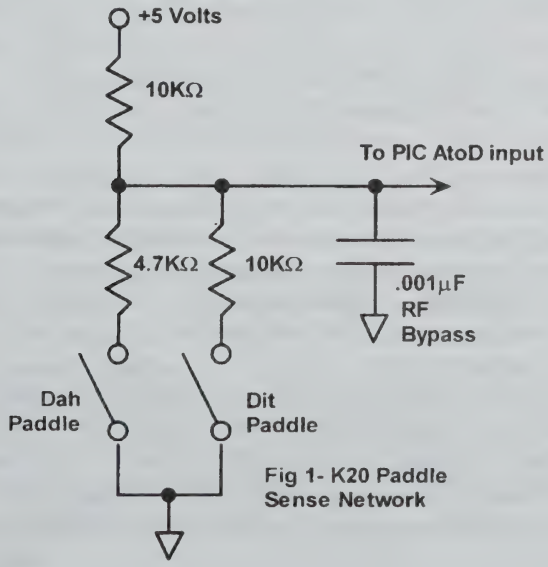



**Fig. 1**

**Two Chips Two Worlds**

Figure 2 is a block diagram of the split architecture. Now that the design had been split, the software program had to be partitioned into two independent pieces. The next sections discuss the result of the design evolution.

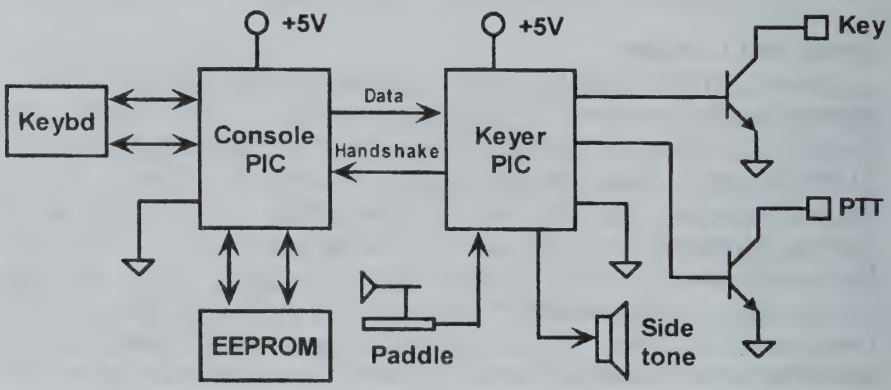



**Fig. 2 Simplified K20 Block Diagram**

**The Console Sits and Waits**

The Console PIC operates in an event driven mode. This means that most of the time it sits in an idle loop waiting for something to happen. Events need to be serviced quickly, but from the PIC's point of view; there is lots of time between events. The two events that trigger the Console into action are keyboard key presses and Keyer PIC being ready to accept data. Since we can generally type much faster than the Morse code we're generating, the overflow needs to be stored temporarily until the Keyer is ready to take it. This is the primary purpose of the EEPROM memory. The Console puts the overflow into the "typeahead buffer" memory and takes it back out when the Keyer is ready to accept it

When a key is pressed the keyboard sends data in serial format to the Console PIC which reads it in, reassembles it, and then parses (examines) it. The data can take one of two paths; be sent as a Morse letter or be treated it as a command. As we just discussed, Morse letters go into the typeahead buffer while commands are treated differently. A command is something that changes the operation of the system in some way, a speed change for example. Commands are of two types, immediate and buffered. Immediate commands are sent to the Keyer PIC right away, bypassing the typeahead buffer. If you make a speed change you usually want it to take effect immediately. If a speed change command were put into the typeahead buffer, all the Morse letters ahead of it would have to be sent first before the speed change could happen. There are situations where you don't want a command to take effect immediately. Let's say we want to send a two part message. The first part at 12 WPM and the second part

at 20 WPM. By inserting speed change commands in the typeahead buffer with the Morse, the speed changes will be delayed and happen at the desired time. Buffered commands are used most frequently in messages, while immediate commands are used on the fly or during keyer setup.

The Console interfaces to the user and must be easy to use. Commands are assigned to function and control keys in a logical manner and all commands have the same basic "look and feel". The availability of a large program space allow lots of features and a sophisticated message language. Configuration commands allow the keyer to be tailored to the user's taste. A setup can be permanently stored in EEPROM so that the operating state can be restored after power off.

**The Keyer is a Clock Watcher**

The Keyer PIC isn't driven by events; it's driven by a real time clock. The Keyer's tasks are time critical and must be done in sync with a reference clock which, in the K20, is 8000 Hz. Every 125 microseconds (1/8000 Hz) the PIC is interrupted. Each time it stops whatever it's doing, and checks a task list. Here's what's on this list:

Receive serial data bits sent from the Console
Generate Morse dits and dahs at the correct speed, weighting, and spacing
Generate a smooth sidetone at a specified frequency
Control PTT output keeping track of lead-in and tail delays
Monitor the iambic paddle inputs
Issue flow control back to the Console

The software routine that checks the status of all these tasks must be very efficient, if it takes longer than 125 microseconds we overrun and miss the next interrupt. Figure three illustrates how interrupt and background processing interleave. Note that the interrupt processing time varies by the amount of tasks that need service.

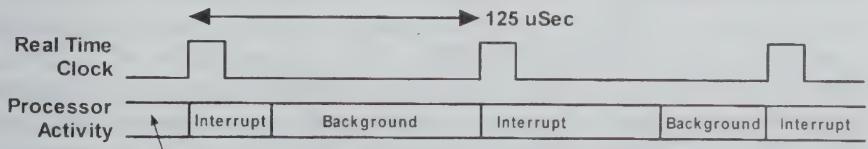



Fig 3 - Keyer Task Interleaving

Some tasks are simple enough to service in the interrupt routine while others take many milliseconds to complete and have to be run in the background. Background processing is what the Keyer does between interrupts. The best way to understand how this works is by some examples:

**Sidetone generation**

It is very easy to generate a squarewave output that can be used as sidetone. For example, a 1000 Hz tone can be generated by toggling a PIC output off and on every 500 microseconds. This works out to be a toggle every four interrupts (4 * 125 mSec). We can generate different tone frequencies by adjusting the count; if we toggle every five interrupts we get a tone of 800 Hz, if we toggle every three we get 1333 Hz. Since counting and toggling an output bit are simple, this task is done in the interrupt routine.

**Send a Dit**

Dit and dah generation depend on accurate timing which is easy in an interrupt driven scheme. To start a dit we assert the key output, enable sidetone, and load a counter with a value equal to the length of a dit divided by 125 mSec. For 5 WPM this is 240 mSec/125mSec=1920. On every subsequent interrupt, we decrement the counter until it reaches zero. When it's zero the dit's done so we de-assert the key output and turn sidetone off. Then we start an inter-element delay which is also equal to a dit time. The beauty of this scheme is that dits, dahs, and spacing can all be accurately timed independently of background tasks.

**What's all this talk about background?**

A speed change command sequence is a good example of background processing. The Console sends data to the Keyer serially, one bit at a time. The Keyer must accurately sample the serial input pin at the correct time in order to pick out the bits correctly. Obviously, something this critical must be done in the interrupt routine. The serial data rate is 1200 baud, which is a bit every 833 microseconds, and data is sent in groups of eight bits (one byte). It takes about 53 interrupts to accumulate a full byte after which the Keyer has to figure out what was sent. Here is where we run out of time in the interrupt routine. About all we have time to do is set a flag that says a full byte has been received and let the background figure out the rest. In between interrupts, the background process sees the byte ready flag and checks if a command or data was received. Since it's a speed change command, two more bytes must be received to obtain the new speed. A 2 and a 0 for 20 WPM. Next, a little bit of math is done to calculate new dit/dah times. The whole process takes hundreds of milliseconds and is constantly interrupted every 125 mSec. Background tasks are not critical so they can take as long as they need to. Even though a speed change could take 400 milliseconds it still seems instantaneous to the user!

If the serial data sent by the Console had been a Morse letter, background processing would be very different. First, the incoming letter would be converted into a binary pattern representing the dits and dahs in the letter. Then one by one the individual elements of the letter are queued

and sent at the proper time by the interrupt routine. The keyer will not start the next letter until the current one is complete.

**Nasty Realities**

Two issues in the K20 design deserve some additional discussion. First, how reliable is the analog paddle interface? Second, what is the life expectancy of the EEPROM?

**Internal RC Oscillator Stability**

The 12C672's internal clock generator is based on an internal on-chip resistor-capacitor oscillator that is not the most ideal oscillator to deal with.

First of all, there is an inherent inaccuracy due to process variation during manufacturing. The Microchip 12C672 specification states that at a 5-volt supply and a temperature of 25 degrees C, the nominal RC oscillator frequency is 4.0 MHz with a minimum of 3.65 and a maximum of 4.28 MHz. This is a range of –9.5% to +7% and it directly affects the absolute accuracy of the K20's WPM settings, time delay calculations, and serial communications clock rate. Microchip's process is quite good and the majority of chips trim out very close to nominal. However, good design practice dictates that worst case must be taken into account. The most serious functional issue is intercommunication between the Console and Keyer. If one chip's oscillator trimmed out on the high side while the other on the low side the communications rates could be off enough to prevent the Console from talking to the Keyer. To counteract this possibility, Keyer and Console chips are programmed in pairs from the same manufacturing lot. Process variances tend to be uniform among parts manufactured at the same time.

The other oscillator error is instability due to changes in temperature and voltage supply. Voltage supply sensitivity is reduced since the K20 has an on board 5-volt regulator. Temperature is a consideration however. Going back to the PIC12C672 specification we find that the frequency can vary from +.3 % to -.6% over a temperature range of 0 to 50 degrees C. This is barely noticeable from a user's standpoint and an error of this magnitude can be tolerated in the serial communication design so it is not of concern.

**Paddle Reliability**

When a paddle is pressed, the voltage applied to the PIC's AtoD input does not change instantaneously. A .001 mF RF bypass cap insures that we ramp between voltages. By examining the paddle resistor network diagram we can see that the "no press" voltage is 5.0 volts and can calculate that a "dit press" value is 2.5 volts and a "dah press" value is 1.6 volts. If we are unlucky enough to press the dah paddle so that it is sampled "on the way" from 5 to 1.6 we could read 2.5 volts and think a dit was pressed. In addition, switch contact bounce adds to sampling error. The solution to

these problems is to perform multiple samples to insure that we have read a settled value. The more samples the better but we can't compromise paddle response time. Three matching samples over a period of 500 microseconds prove to be very reliable. Follow-up measurements with an oscilloscope found the worst-case delay of this scheme to be about 1.4 milliseconds. If we are sending at 20 WPM this is a delay of approximately 2.5% of a dit time which is imperceptible.

To decrease sensitivity to resistor tolerance the PIC looks within a range of values to distinguish between paddle states. The high and low limits take into account worst-case resistor tolerances so that inexpensive 5% or 10% resistors can be used. Dirty paddle contacts can cause problems. If a paddle press voltage is not stable due to paddle contact resistance the PIC may have difficulty obtaining matching samples and a paddle press could either be delayed or ignored. The high resistance values used in the divider network reduce contact resistance sensitivity considerably, but a contact instability greater than 80 ohms can cause problems.

**EEPROM Life**

The second "nasty reality" is the use of EEPROM for the typeahead buffer. For all its advantages, EEPROM has one big disadvantage; a nominal life of one million erase/write cycles (for a Microchip 24LC16B). This means if you pick a location in the EEPROM and write to it one million times the manufacturer no longer guarantees that the location can be written again reliably. So do we have a ticking time bomb? Is the K20 going to just stop working someday? Well, the correct answer is yes... if you use it long enough. Some simple math shows: one million accesses multiplied by 200 locations in the typeahead buffer give us 200 million guaranteed keystroke writes. Now, if we sat down and started typing at an even rate of 35 WPM we could send ***non-stop*** for (200,000,000 letters/(35 words/min * 5 letters/word)) = 1,142,900 minutes = 793 days or slightly over two years. If you back off a bit and only send for four hours a day, that time increases to thirteen years !

**Wrapup**

That's a quick look at some design issues of the K20. Kits are available at a low cost to entice folks to build and learn. A kit including PC board and board mounted sells for $25. You supply the following components: a case, power supply, and connectors. The PC board is a breeze to assemble, all through-hole, with a forgiving layout that is easy to solder. Further information is available at www.k1el.com.

## The Rochdale Mini QRP Convention 2000

by Dick Pascoe G0BPS Dick@trickie.com

The end of October each year sees the premier QRP event in Europe, another one of those special things where you are not a European into QRP unless you have been at least one.

The Annual QRP Mini QRP Convention is held at the Church of St Aidans in Sudden of Rochdale in the north East of England. It is the also the home parish of one of the most well known QRP'ers in the world. The Rev George Dobbs G3RJV has run the convention with the aid of a few friends (and of course his wife JoAnna G0OWH) for the past 12 occasions.

This is not a British Hamfest in any sense of the word, it is a genuine convention held in true QRP style in a small Church hall. If more than 350 turn up we are in trouble!

The hall is set out in the same way each year with a ring of QRP related traders around a central area for visitors to sit and chat. The doors open to visitors at 10am (ish) and depending on the cold British weather at this time of year there may be a small crowd of three or four waiting to get in. The weather this year has been awful with heavy rain and floods all over the UK. We even had snow in Rochdale the Monday after the convention!

The style and flavour of the convention hasn't changed over the years. The faces change slightly but not much. I seem to remember Roy Lewallen W7EL saying that in the 70's he was the average age of a 'Ham' here we are; thirty years on and we are still the same. The same age as the average 'Ham' where will we be in thirty years time?

Visitors in the past have included several from the US. Luke Dodds one time treasurer of the ARCI and their (then) President Paula Franke has both been over. Even Derry Spittle from Canada has been a few times. A few more have also made it but we still wait to welcome the top guys of NorCal. Rumours have it that Doug is sneaking over the puddle next year! We truly hope so. Other visitors come from all over Europe and include some top names in their Country. Petr OK1CZ, Peter PE1MHO, Rudi DL4UH, Rene ON4KAR.

The day passes quickly with the speakers actually using the Church for their forums, complete with Overhead projector and Mic. Speakers this year included Tuc Choy from VK land (missed his call) and the usual Rob Mannion from Practical Wireless Magazine. Visitors to Dayton will remember Rob with pleasure. Rob has a regular spot each year covering the happenings through the UK.

The other regular spot is that of David GM4ZNX. David is one of those very rare beasts who have what is called 'Total Recall' what may seem a boon to some could be a difficulty to others. Ask David a question and he will answer it. ANY question! If you don't understand his reply first time he

will gently lower his standard until you do. I have listened to him describe the inner workings of a Spectrum Analyser to one and a few moments later describe a diode to another. Without making the listener feel awkward.

Without doubt the lunch is the highlight of the day, except this year there was a terrible failure on the part of George G3RJV to actually determine that the lunch was complete. We ALWAYS have 'meat pie, mushy peas and pickled red cabbage'. This has become a favourite of all attending. This year George failed to order the 'mushy peas' and we has a pealess lunch.

The wives of helpers, and ladies from the church muddle in to work the kitchen and for the past 12 years it has helped keep my wife busy and out of my hair so I can enjoy myself!

This is a very friendly show, as almost everyone knows everyone else. If they don't when they start, they do when it finishes.

The helpers are invited back to the vicarage in the evening after we have all cleared the hall and got it ready for the Sunday morning hordes. Johhny Appel and his wife Birgita usually add to the piles of Chinese food. Their salmon and herring dishes brought in from SM land are gorgeous. (I usually ignore the Chinese food until the fish has been well tested).

Friday is hall set up day and those who arrived early get stuck in and get the entire table and chairs set out. Sunday is wind down day with a visit to Church with George and JoAnna and a leisurely lunch to follow at a local hotel.

If you are tempted to visit the UK soon then beware, this event is VERY laid back. No hustle and bustle and no pressure to do anything except enjoy yourself. We open the doors at 10am and the last visitor usually is gone by 4pm. We are typically clear by 6pm and sat with a well-earned drink in our hands.

Local hotels are available from $50 upwards with a few cheaper ones a little further afield. You could fly direct from the US into Manchester, which is a 30-minute cab drive from Rochdale. Of course you could make it part of your annual vacation.

The UK is very small compared to the US we are under 1000 miles from the northernmost part of Scotland to the southernmost part of England. We can drive a little faster than you too, with luck and a blind eye from the local bobby (police officer) you can cruise easily at 85mph on our motorways (freeways) though the legal limit is 70mph.

If you fancy jumping the puddle in the near future please let me know and I will offer any advice that I can. I don't know all of the UK but I am certain that I know a man that does.

Finally I would like to reiterate a comment from WB9TBU when she visited Dover Castle near where I live. She saw some graffiti on a wall in the castle covered by a plastic sheet to protect it.

I explained that prisoners of war had done it. Not those from WW2 or even WW1 but from the Napoleonic wars in the 1700's. When France and

England were at war. Her comment will stay with me always. "Gee, you have graffiti on walls older than we have buildings" Dover Castle was built in the 1400's.

Please do join us some time for Europe's very best Mini QRP Convention. We would really love to see you there. Email me for more information at Dick@trickie.com

George Dobbs, G3RJV accepts $700 from Graham Firth, G3MFJ, on behalf of the NorCal QRP Club as a donation to the Parish Fund of St. Aidan's Church, where George is the Vicar. The money was raised by a raffle of QRP kits at Pacificon 2000, which was won by George Heron, N2APB. NorCal members were very generous in their donations, and St. Aidan's Church is very appreciative of the gift. The presentation took place at the annual Rochdale Qrp Convention held in St. Aidans.

## QRP To the Field: 2000

by Jan Medley, N0QT

NorCal Contest Manager

Here are the final results from QRP To the Field 2000 held on the last weekend in April this year. A total of 81 log entered and tons of great pictures. Keep up the great work gang!

**MARINE MOBILE STATIONS**

| Call | QSO | FINAL | Call | QSO | FINAL |
|---|---|---|---|---|---|
| NQ4RP | 121 | 319700 | WB3GCK | 40 | 51775 |
| W0CH | 86 | 209975 | NQ5RP | 28 | 32000 |
| W5KID | 34 | 66150 | NK3ST | 17 | 18275 |
| NS8O | 32 | 51975 | K7FD | 15 | 6840 |

**OCEAN STATIONS**

| Call | QSO | FINAL | Call | QSO | FINAL |
|---|---|---|---|---|---|
| N0UR | 150 | 443920 | AL0HA | 46 | 61600 |
| N9AW | 142 | 375840 | W3CD | 34 | 42680 |
| AE9K | 118 | 288080 | WA6NAE | 42 | 39040 |
| K2QO | 94 | 223380 | N4JS | 29 | 33200 |
| W9XU | 89 | 203320 | N6WG | 43 | 16380 |
| K0ZK/1 | 65 | 120080 | WA9WAC | 21 | 11000 |
| NK9G | 66 | 98340 | KI6DS | 20 | 10080 |
| W0UFO | 58 | 93000 | | | |

**OTHER WATERS STATIONS**

| Call | QSO | FINAL | Call | QSO | FINAL |
|---|---|---|---|---|---|
| AA5B | 153 | 400995 | AC6NT | 31 | 29700 |
| W0CQC | 140 | 269280 | WT9S | 28 | 29520 |
| N4DD | 126 | 247950 | KF2EW | 37 | 28800 |
| WA7LNW | 116 | 234900 | AB8DF | 30 | 26070 |
| AK7Y | 102 | 164820 | KD3FG | 27 | 22500 |
| W5TB | 92 | 160740 | N5SAN | 26 | 20520 |
| N7KE | 95 | 159285 | NK7M | 25 | 20250 |
| K4JSI | 61 | 145920 | VE6QRP | 24 | 16065 |
| K7RE | 80 | 112800 | W4IM/8 | 28 | 15555 |
| WD7Y | 69 | 107070 | AE5X | 23 | 14280 |
| K5HQV | 61 | 100035 | KF4AR | 11 | 5550 |
| AF5Z | 61 | 93480 | VE3SMA | 20 | 5520 |
| W7TAO | 50 | 66030 | AC6AN | 12 | 5265 |
| K5AAR | 58 | 62250 | KI0KY | 10 | 4200 |
| N7TX | 49 | 59220 | K6UIZ | 10 | 840 |

| | | | | | |
|---|---|---|---|---|---|
| K7TQ | 50 | 56280 | K2HPV | 6 | 810 |
| N7KT | 37 | 40455 | N3FZX | 3 | 90 |
| WA5BDU | 42 | 33705 | | | |

**FIELD STATIONS**

| Call | QSO | FINAL | Call | QSO | FINAL |
|---|---|---|---|---|---|
| W4GGM | 65 | 57400 | KE9GM | 33 | 11830 |
| AD6GI | 38 | 23920 | KG9PQ | 19 | 6720 |
| W0YSE | 31 | 20880 | N1IRZ | 14 | 3150 |
| AF4PP | 29 | 15480 | WA9YDJ | 12 | 1900 |
| AB5XQ | 25 | 14820 | WA9PWP | 3 | 270 |

**HOME STATIONS**

| Call | QSO | FINAL | Call | QSO | FINAL |
|---|---|---|---|---|---|
| K5KW | 144 | 97150 | N0IBT | 25 | 5130 |
| W1VT | 92 | 59045 | AA9NF | 26 | 5025 |
| N8XI | 102 | 58650 | AL7FS | 14 | 1870 |
| NQ7X | 63 | 30970 | VE5QRP | 10 | 1215 |
| N9MZP | 46 | 20880 | JR0BAQ | 10 | 870 |
| W3MWY | 27 | 8470 | | | |

**CHECKLOGS**

| Call | QSO | Claimed |
|---|---|---|
| AE6N | 26 | 15120 |
| W7/JR1NKN | 9 | 6480 |

81 Logs Submitted

**Soapbox:**

Hello again QRPer's. It is very much fun to join QRP contests held in stateside from Japan! I hope that more DX stations (from your side) will join to these contests. I could not operate from outdoor because the time was from midnight to morning here! (0000-0900 local time). Kohei, JR0BAQ

I only wish I had known about the Water World thing earlier as my seafaring family, of which I am but one, would have provided space on any of a dozen vessels. Ha! George, W3MWY

I'd like to see the Water Theme run again if possible because we have a small manmade lake in the middle of Regina. Even though I have a low score, it was fun and therapy and that's why I enter. Many thanks to all who made this event possible! Bruce, VE5RC/VE5QRP

[Well said, Bruce. I like field contests because it gives us all a chance

to drop out of the fast lane for a few hours and a good reason to get together with friends — Jan.]

Very tough conditions today. I worked only 3 QSOs in the first 90 minutes starting 1800Z. It was fun in spite of it all. Thanks to everyone for being there. Jim, AL7FS

Very fun contest. Had hoped to operate from my boat on the Mississippi River. Had to settle for home operation this year. Pete, AA9NF

Had plans to try the Ocean (Lake Huron or Erie) on my brother-in-law's boat. But, took on baby sitting duties with a couple of grand kids. Managed to work a few on 40, 20, 15 but heard no one on 10. Rick, N8XI

[Nice job anyway Rick, all the way around! Hope your grand kids will take an interest in amateur radio since they have a great Elmer in their grandpa — Jan.]

My first QTTF. Great fun! Could not make it to the water, so set up in my back yard. Put up a temporary dipole at 20 ft. Powered rigs with a 12V car battery and sat under a shade tree — Beautiful day! Bill, AB5XQ

I sneaked away from manning an all-day display at the mall to work a few QSOs from the parking lot. The "QRP section" of 20 meters sounded pretty lively, and it seemed like a lot of folks were getting in on the fun. My worst QRM came from massive, megawatt car stereos driving through the parking lot, blasting sound waves through the padding on my headphones. Dave, N1IRZ

Thanks for organizing this event. It was great fun and a perfect day — clear, sunny, and temperatures in the low 70's. Total operating time was 2½ to 3 hours, so was also able to get lawn mowed, oil changed in the car, trip to bank and PO, visit to nursing home, etc. (the usual Saturday "Stuff") done also. Chuck, AF4PP

Weather & other interruptions prevented me from doing as much operating as I would liked to have done — But I got to test my new 35 ft. portable mast consisting of a 10 ft. metal conduit, an 8 ft. dowel & topped with the Black Widow fish pole. Thanks for the contest — it was great fun! Neil, W0YSE

[Neil sent in some great pictures of his antenna — would make a great article for QRPp Neil! — Jan.]

This was my first contest with my new DSW 20 QRP kit. Great way to break it in!!!!! Cal, KG9PQ

My first solo effort in a QRP contest. What a refreshing difference from QRO 'tests! It's nice to receive TRUE sig reports, instead of meaningless 599's all day long ... and QRP ops are much more polite during contests. I'm hooked. Steve, N7TX

[Thanks for the pat on the back, Steve. QRPers are a breed of their own, and we're a fun-loving bunch to boot — Jan.]

Great weather. Had lots of fun. Will be back next year. Ed, AB8DF

Man I love these field events, way too much fun. Propagation was poor, but the camaraderie was, as always excellent. Thanks to NORCAL, and all the folks who worked so hard to make this possible for all of us. Brian, K7RE

With rain in the forecast, I wasn't planning to operate and had no site picked out. But wx was perfect and I couldn't resist getting on! After some time exploring, I picked a pleasant spot on the bank of a stream and spent an enjoyable hour and a half on the air. Steve, VE3SMA

Great fun, after we ran Murphy off. The new DK9SQ mast collapsed, shattering the new DK9SQ loop matching box, so had to use the High Sierra screwdriver antenna. Had to cobble up the power cord for the K2, the original being back in the shack. Beautiful site, with a great view overlooking the lake. Very windy, though. Propagation not too good, but fun anyway. Bob, NK7M

[Bob, a lot of us have those DK9SQ masts and we all seem to have the same problem with them...collapsing! Let's make an appeal to the "Think Tank" and maybe there is a solution. I have 3 of the darned things — Jan.]

Took a canoe trip on Snake River in WA to my QTTF site. Great time! Randy, K7TQ

Another great contest by NORCAL! Conditions were not great and the high winds broke my antenna support lines twice, but had lots of fun. Greg, AK7Y

Heavy winds created a big of a challenge with antenna installation. Otherwise, terrific fun!! Jack, WA7LNW

Great contest! Warm, windy, lots of bikinis... Roger, N7KT

This is my second time operating QRPTTF in the field, so much fun, looking forward to next year. Ed, WD7Y

Great theme! Too bad our MM plans fell through at the last minute. Can't wait for next year's theme. Bruce, N7CEE/W7TAO

**And This Says It All...**

This was my very first QRP contest — had finished my DSW-40 a few days ago and wanted to try it out. Worked 1600-1715Z, 1830-1930Z, and 2100-2300Z, but should have concentrated my efforts on the last 3 hours — east coast stations were starting to roll in. Up until a few days ago, I had been inactive for 25 years. QRP has grabbed me, though, and I'm looking forward to next time. I had a lot of fun even though I didn't work many stations. Thanks for a most enjoyable activity! Propagation conditions didn't seem that great during much of the contest, however. Vance, WA9YDJ

[QRP is fun and challenging so welcome aboard, Vance. There are lots of contests out there that are QRP only or have QRP categories, but even if they don't you can still submit your log as QRP anyway! I just send mine in as SO/QRP at 4W. Sometimes they add a QRP category to contests because they are getting more and more QRP logs! — Jan.]

Had a great time in my first QRPTTF. Bands seemed a little weak, so I took a long break to mow my yard :) — I was set up on a hill at the back edge of my property, overlooking my pond. Lots of good ops out there. Jay, WT9S

QRPTTF 2000 was a great outing. I took along N4UW, Luther, for his first QRPTTF. Conditions were good and we had lots of fun. Thanks for another great contest and we look forward to the next. Dennis, N4DD

Jon Mitchell, KD3FG, writes:

Ken, N3FZX, and I went to Scott's Cove in southern Howard County, Maryland (part of the Patuxent River State Park). We set up right near the water line and had to deal with the QRM from the various water fowl.

We assembled the fishing pole vertical and threw up a folded dipole in the trees. This dipole is becoming my favorite trail antenna due to it being cheap, it is easy to put up and it works really well on the bands! I built it with three 50 foot rolls of cheap Radio Shack 300 ohm TV twinlead. I was not able to get a good match on the vertical (poor planning on my part — I usually set the coil before an outing), so we really only used the dipole.

Ken had just finished his TAC-1 40m rig and this was the first time I had my K2 on an outdoor contest. Both radios performed well.

Ken and I alternated operating times on an hourly basis. I got in almost three hours and was able to work 27 stations. This is better than last year's score of 25 after 4 hours, so I am happy with the results. Ken scraped up three contacts (one being W1AW) in the novice section of 40m.

From the Redmond Top Key Contest Club, N7KE:
Ops — NW7DX, KB7N, W7HQJ, W7QC, W7ZF, KK7UT, W7HLO, K7SZL, W9HXM

Well, another wonderful time had by the N7KE clan. Our station was set up at Lake Cavanaugh WA, and had a beautiful view of the water and mountains. We got off to a bit of a slow start, but really pulled it together as time went on. By the end of the contest we had racked up 95 QSOs, which is the club's all-time best. Our total SPCs was 41, which is also our best. Most of our operation was on 20 meters, but there were a lot of Monster signals on 15 meters as well! Our antennas were a 20 meter double zepp, and a double-delta loop array, for 20 meters also. These were fed into our K2 and Red Hot 20 (everybody int he club absolutely loved these rigs). Both were excellent performers.

When I (Ben Schupack, NW7DX) was in front of the rig, I heard many familiar calls and some new calls too. It sounded like the activity this year was up quite a bit from last year. Hopefully, it will be even more active next year. It sounded like towards the end of the contest, everyone was begging for contacts.

It was fun hearing all of the portable stations. Many of them had huge signals into the Northwest. Never did hear Jim (AL7FS) up there in AK, but did manage to work a Japanese station which was very nice.

I hope everyone had as much fun as I did. It was a great way to spend a Saturday afternoon.

TE "Doc" Drake, W5TB, writes:

Worked 3 hours in AM — set up at a picnic table under oak trees in a lovely park. Had to QRT at noon to join my Labrador retriever for a fund raising walk for the Pet Rescue Society. When I returned at 3:30, I discovered my double zepp *gone*! I found someone had stolen the ropes and trashed the antenna - which I found pieces of in the grass. Rather than quit, I hastily twisted the pieces together to form a random wire and counterpoise and was back on the air by 4 pm to complete the contest with another 44 QSOs (92 QSOs in all!)
[QRPers are sure an ingenious breed of people — Jan.]

From Nick Kennedy, WA5BDU:

This was my first QRPTTF because usually the date collides with the Little Rock hamfest. Not this year.

The Site: There's a valley between Tibet and China walled off by mountains and almost completely inaccessible to humans. It features beautiful, towering waterfalls. I didn't go there.

At the back boundary of my yard is a creek, poeticcally named "Engineer's Ditch" on city drainage drawings. Completely grown up with underbrush, it's almost as inaccessible as that place in Tibet. It flows year round and occasionally leaps its banks and threatens my house. If you're

wondering if it's a real creek, it even has fish in it....okay, minnows. Also, there are fierce mosquitoes in the area of my yard. They are Laotian or something, have striped socks, and will bite you right through your Levis.

The Stuff: I set up my card table in the creek bed with one leg in the water. Spent the usual hour or more doing my Charlie Brown With Kite routine and finally got my dipole up a good 40 feet or so. I used my Red Hot 20 and an MFJ tuner plus choke balun. A 4-AH gel cell from BG Micro. Arkiecon 2000 QRP Mini-logbook from Doug and an old fashioned paper dupe sheet.

The Results: Not too bad for single band operation. Think I made about 40 QSOs. Didn't even work CA, WA or OR. Worked only one VE. Worked lots of zeroes, lots of CO and NM. Only celebrities I worked were Dr. Megacycle and W5KID. Worked a few county hunters. What are you supposed to say to 'em?

The gurgling of the creek was nice. And the roar of lawn mowers and my neighbor's backhoe added a Field Day kind of ambiance. Plus, there were leaf blowers, weed eaters and young guys with their Thump-Thump-Thump car stereos cruising by occasionally.

Several operations sent in photos. These have been placed on the NorCal Web Site at http://www.fix.net/norcal.html Check the great photo essay work done by our photographers in the field, our contest manager, Jan Medley, N0QT, and NorCal Web Meister, Jerry Parker.

# The Epiphyte 3, A 75 Meter SSB Transceiver

**Designed by Derry Spittle, VE7QK**
**A NorCal QRP Club Kit**
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*[The Epiphyte 3 is a remarkably simple, easy to build SSB transceiver for 75 Meters. It uses simple parts, which used to be easy to find. Sadly, some parts for this transceiver are very difficult to find in quantity, although it is possible to find them in lots of 1 or 2. NorCal kitted 100 of these transceivers in September, and they sold out in 1 day, less than 24 hours. We have been planning this kit for 4 years, and have had some parts for that long. We will not do another run of the kit, but present the manual here for those who might want to attempt to build their own, with salvaged parts from Epiphyte 1's and Epiphyte 2's. The club does have 40 PC Boards that are for sale for $12 each. To order, send a check or money order for $12 to Jim Cates, 3241 Eastwood Rd., Sacramento, CA 95821. Please enclose a self addressed mailing label to help Jim out. As always, please make checks and money order to Jim Cates, NOT NorCal. We do not have any parts available for the boards. You are on your own on that one. We hope you enjoy the article, as it has been a long time in developement. Doug, KI6DS]*

## INTRODUCTION

***EPIPHYTE, a plant growing on another [f. EPI + Gk. phuton]O.E.D.***

The original Epiphyte was a simple transceiver designed to provide voice communication with the British Columbia Public Service Net on 3729KHz from wilderness areas of the province. It ran off AA batteries, was light enough to backpack, and had an output of one watt. Construction articles were published in both QRPp and SPRAT, circuit boards became available and fifty kits were produced. While only a few amateurs used it for the purpose for which it was originally intended it did succeed in introducing many of them to home construction of SSB equipment. It was fun to build and play with.

The Epiphyte-2 included a VFO and the power output was increased to five watts. Once again, construction articles were published and circuit boards became available. In 1996 the QRP Club of Northern California and the G QRP Club, as a joint project, donated fifty EP-2 kits to amateur operators in Third World Countries. It now features in the QRP section of the RSGB Radio Communication Handbook and feedback from amateurs around the world confirms that many have been and continue to be built and operated.

So how does the Epiphyte-3 differ from its predecessor?

The circuit board has been re-designed and professionally manufac-

tured with plated-through holes, solder resist and screened parts overlay.

· The antenna connector, power connector, switch, RF gain control and lowpass filter are now installed on the circuit board reducing the number of external connections.

· Audio-derived AGC has been added to the receiver.

· Polystyrene capacitors have been replaced with smaller and more readily available NPO/COG ceramic capacitors.

· The power amplifier has been heat sinked to the base of the enclosure. The improved the heat dissipation permits it to operate at higher power without overheating.

The NorCal kit includes the circuit board and all components which are directly mounted on it the 10-turn tuning pot and terminal housings for the Molex headers. You will need to find very few parts on your own to get your EP-3 on the air.

Assembly is not intended to be a "winter construction project". Any amateur with some previous experience at building HF equipment and working with printed circuit boards will have little difficulty in assembling the EP-3 in a few evenings. Nor is it intended for the serious contester.

I hope you will have as much fun with it as I have. Feedback, suggestions and constructive criticism are always welcome,

Derry Spittle, VE7QK
North Vancouver, BC, Canada
e-mail: jds@vcn.bc.ca
September, 2000

**ACKNOWLEDGMENTS**

First and foremost to Doug Hendricks, KI6DS, and NorCal for funding most of the development costs and making the EP-3 available as a kit; to Ed Burke, KI7KW, Dave Meacham, W6EMD, and Graham Firth, G3MFJ for assembling and testing prototype boards. Their advice and suggestions led to a number of changes being made; to Wayne Burdick, N6KR, for allowing me to 'borrow' the AGC circuit from the SST transceiver; and Vern Wright, W6MMA, who assembled the final version without a manual, and has sinced worked me /M from Sacramento.

**THE CIRCUIT**

Refer to the Block Diagram (Diag. C).

The EP-3 is based around a pair of NE602 double-balanced mixers U2 & 3 and a miniature 455KHz SSB filter F1. U6 (4066) switches the LF and HF oscillator between the mixers enabling them to be used for both transmitting and receiving.

The pre-amplifier U4 (LM741) is designed for an electret microphone and the audio amplifier U5 (LM386-4) will comfortably drive a small speaker.

The LF oscillator Q2 (MPF102) is tuned to 452.6KHz to produce an upper sideband signal at the output of the filter.

The HF oscillator Q4, or VFO, (MPF102) is tuned 452.6KHz higher than the output frequency to generate a lower sideband signal at the output frequency.

Conversely, when the oscillators are switched the receiver will demodulate a lower sideband signal in a similar.

The RF bandpass filter L3/L4 has a bandwidth of 200KHz and a steep cut-off to ensure adequate attenuation of the image frequency 900KHz higher. The filter terminates in a low resistive load at the input to U1.

The driver U1 (CA3020) is a high gain differential amplifier. A trifilar wound broadband transformer T2 matches the push-pull output to a resistive load at the gate of the Mosfet power amplifier Q1 (IRF510). Another broadband transformer T3 matches the power amplifier to a 50 ohm load.

L2/L3 is an elliptical lowpass filter. Both sections have been designed to afford maximum attenuation of the second harmonic of the output frequency.

Transmit/receive is accomplished with a miniature DPDT relay K1. One section of K1 switches B+ supplies. In the open position (receive) the voltage is removed from the microphone pre-amplifier U4 and the driver U1. Forward bias is removed from the power amplifier Q2. Closing the relay (transmit) removes B+ from the audio amplifier U5. At the same time this section provides the switching voltages to U6.

The other section of the relay connects the receiver input to the antenna via the lowpass filter when in the open position. It disconnects and grounds the receiver input when the relay is closed.

A simple audio-derived AGC is used to control the gain of the second mixer. For this to work effectively the gain of the audio amplifier must remain high. A manual AF gain control has been omitted. The RF attenuator at the input sets the audio level and only requires adjustment if an extremely strong signal overloads the first mixer. If headphones are used an attenuator in the lead will reduce the output to a comfortable level along with mixer noise.

An LED, inductively coupled to the antenna lead provides a simple modulation/power indicator

| | |
|---|---|
| Output | 8 watts PEP |
| Input voltage | 12 - 14 voltage DC |
| Band | 3.5 - 4.0 MHz |
| Coverage | Set to any 200KHz section |
| Sideband | Lower |
| Circuit board | 2.9in x 6.0in |
| Total current drain | Receive: 50 - 100mA with speaker |
| | Transmit: 150 - 900mA with normal speech |
| Power supply | 2.5 amp AC power supply or 5Ah gel-cell |

**ASSEMBLY**

A small clamp-on table vise great help. Cover the jaws with plastic

tape and always grip the circuit board by its edges.

I recommend that you make a temporary chassis from a 6" x 6" (minimum) piece aluminum for testing and alignment rather than use your final enclosure. Bend one side to form a 2" panel and mount the circuit board along the rear edge on the four threaded metal spacers provided. Use long screws and fasten it to the chassis with nuts on the underside. Screws and metal spacers may be left attached to the board throughout assembly.

All holes in the circuit board are plated-through. Never attempt to enlarge or drill them out. Adequate clearance has been allowed to permit the components to drop into place. If you have to unsolder and remove any component, avoid applying force. If a capacitor or resistor costing pennies does not come out easily, clip it in half and unsolder each piece separately.

The component layout is screened on the circuit board but bear in mind that the part number will often be obscured once the component has been installed. Refer then to the printout (Diag. E).

You can, of course "empty the bag, populate the board and smoke test". The following approach reduces the chance of mistakes and time-consuming trouble shooting later.

· Start with the BNC antenna connector J1. Make sure that it sits both flush with the face and square with the edge of the circuit board. Avoid applying too much heat as this will melt the connector housing.

· Install the power connector. Again, make sure that it is flush and square with the edge. One or more of the tabs might require filing down as their width appears to vary between manufacturers.

· Install the on/off switch SW1. Solder the mounting tabs first and make sure that it is vertical before soldering the leads.

· Install the five IC sockets. Check that each is correctly oriented, flush with the board and that all the pins protrude through the hole. If you start by soldering two diagonally opposite pins it will allow you to square up the socket before soldering the remainder.

· Splay the twelve leads of the driver amplifier U1 out about 30 degrees over a piece of 3/8" round material such as cap of a pen and then straighten the ends. Commence by inserting lead #12 (located beneath the tab) into the corresponding hole on the board. Working clockwise you will be able to insert four or five leads without any problem. Do not insert them any more than is necessary to keep them in the holes. Then use a pointed Xacto knife to guide each of the remainder into place. With luck you will reach pin #1 before pin #12 slips out! Centre U1 about 1/4 inch above the board. Double-check to be absolutely sure that it is correctly oriented before soldering in place.

Install the antenna current sensor T3. This is difficult to install once surrounding components are in place. The single turn primary winding passes once through the core and does not wrap around it. Tighten this as you solder in and it will hold the core in place. The secondary winding is a

470 ohm resistor R24 which limits the current in the D7. Center the body of the resistor through the core and form the leads as necessary to reach the pads. Make sure they do not contact the ferrite core.

· Install the Molex headers CON1 - 5. D5 will be mounted in a terminal housing (to permit disconnecting AGC). Install CON5 in it's place on the board.

Install the headers for the metering jumpers J3 & 4.

Turn now to the capacitors and refer to the parts list which lists them in groups by size and type. I recommend that you install them one at a time, trimming the leads as you go and striking them off on the parts list. Mount axial capacitors so that the markings remains visible after installation.

· Commence with the 470mF and three 100mF electrolytic capacitors. Make sure that they are correctly polarized and flush with the board.

· Install the two 10mF and five 1mF tantalum capacitors. Again, be absolutely sure that they are correctly polarized.

· Install the 1mF non-polarized ceramic capacitor C10. Re-form the pins to fit the hole spacing if necessary and try not to damage any molded stand-offs.

· Install the fourteen 100nF (0.1mF) ceramic capacitors.

· Install the four 10nF (0.01mF) capacitors.

· You will have noticed that C32 appears twice in the parts list. 5600pF, despite being a standard value, was unavailable. 4700pF in parallel with 1000pF has been substituted. Stack the caps above one another and feed two leads through each hole. They fit easily providing you don't twist them together.

· Install C33A 1200pF polystyrene cap. This is in parallel with C33 but this time separately mounted.

· Install the three 2200pF ceramic caps.

· Install the four remaining 1000pF caps

· Now sort out the seven 680pF caps. Install the two COG caps C40 & 41 in the VFO before installing. the remainder. Why two types? COG caps were not available with the 100V rating for the lowpass filter.

· Sort out and install the remaining fifteen ceramic caps.

· Finally, install the trimmer cap C56

· Verify that all caps are accounted for both on the board and out of the bag.

**Turn now to the resistors**.

· Install the 21 fixed resistors. For those mounted vertically, form one lead into a 0.1"D semicircle close to the body using the tapered end of a pencil.

· Install the multi-turn trimpots R19 & 20 and orient the adjusting screws as in the parts layout and photograph.

· Insert the shaft in R22 and install. Make sure the pot is square and the shaft horizontal before soldering in place.

· Install the 10-turn precision pot R24 in the center of the panel of the

temporary chassis.

· Install the voltage regulators U7 & 8. U7 is the 8V regulator and U8 is the 9V regulator.

· Install the reverse polarity protection diode D6.

· Install the SSB filter F1 flush with the board. Avoid overheating and do not trim the pins.

· Install the relay K1 flush with the board.

· Install the ceramic resonator X1.

**Before proceeding you can carry out some DC voltage checks.**

· Install the PC board on the temporary chassis. Leave the switch in the off position (down). Do not install any ICs or shorting jumpers.

· Obtain the parts to make up a power lead. Include an inline 5A fuse. The reverse polarity protection is a shunt diode so do not omit the fuse.

· Connect to a 12V DC power supply. If the fuse blows, then either the polarity of the supply is reversed or the protection diode was installed backwards. Rectify this before going any further.

· Place the switch in the on position and check out some voltages with a multimeter. You should be reading 8V at pin 8 of U2 and 12V at pin 6 of U5. No voltage should appear at J4 and pin 7 of U4.

· Ground pin 1 of CON1 to close the relay. You should read 8V at pin 8 of U2, 9V at J4 and 12V at pin 7 of U4. No voltage should appear at pin 6 of U5.

**This completes the test.Refer now to the list of semiconductors.**

· Install Q2, 3 and 4 (MPF102).

· Install D1, 2, & 3 (1N914) observing the polarity. The cathode end is marked with a black band. D1 is mounted horizontally and the cathode end is identified in the parts layout. D2 & D3 are mounted vertically and their cathodes grounded. Form the cathode leads into a 0.1" semicircle. The grounded traces on the board are easy to locate if you are uncertain.

· Install the varactor diode D4.

· Install LEDs D5 & 7 in 2-pin polarized Molex housings but do mount them on the headers at this stage. It is essential to observe the polarity of D5 or the AGC won't operate. While the polarity of D7 is unimportant you should polarize it the same way as it is unable to tell them apart later!

**Refer to the list of inductors**

· Identify and install the 1000mH choke L11 (epoxy-coated). If you have any doubt measure its DC resistance with an ohmmeter. It should read around 12 ohms.

· Install the three 1000mH chokes L7, 8 & 9 (molded). Form the leads of L7 & 8 as you would for a vertically mounted resistor. Avoid sharp bends near the body as the internal connections are quite fragile.

· Install the four Toko variable inductors L3, 4, 5, & 6. Install L 6 (VFO) first. The remaining three are identical. Use a small solder fillet on each of the mounting lugs to ground and fasten them to the circuit board. It is unnecessary to solder any of pins other than the 2 outside pins of the 3-pin

row. The remainder do not connect to anything.

· Identify the iron powder toroid cores for L1 & 2 (red). Wind each with 20 turns of #24g enameled wire leaving half inch leads. Scrape clean and tin the leads close to the core before installing.

· Identify the ferrite core for L10 (black). The manufacturer lists this as a "bead". Wind with 12 turns of #24g enameled wire leaving one inch leads. Leave the leads long enough for the core to mount in line with the pads clear of adjacent components.

**Refer now to the list of transformers.**

· Start with the power amplifier output transformer T2 which is wound on the ferrite binocular core. The primary winding (connected to U1) comprises 2 turns of #24g enameled wire. Pass the wire through each holes twice which leaves both leads projecting from the same end of the core. The secondary winding comprises 5 turns of #26g wire and starts from and finishes at the opposite end of the core. Trim the leads to half inch, tin and install.

· T3, the antenna sensor was installed at the beginning.

· Turn now to the driver output transformer T1 which comprises 5 trifilar turns wound on the remaining ferrite bead. For those of you who have a problem with trifilar windings the following may help. Take three 10 inch lengths of #26g enameled wire and knot them together at each end. Clamp one end in the chuck of a small hand drill and the other in a vise. Keep the wires taut and twist to about 10 turns per inch. Cut off the damaged ends and wind 5 evenly spaced turns on the core. Unravel (rather than untwist) the ends back to the core, straighten and trim each of the 6 leads back to one inch. Clean and tin back the first half inch only or they may short together or against the core. Identify each of the three windings with an ohmmeter. Referring to them as "AA", "BB" & "CC" install T1on the circuit board as below. Pull each lead through leaving a small portion of the tinned section visible above the top pad before soldering.

**Power amplifier** **Driver**

## TESTING AND ALIGNMENT

Most of the testing can now be carried out before the power amplifier is installed. The IRF510 pins are brittle and easily bent when the circuit board is removed. It is better to delay installation until you are satisfied that everything else is functioning correctly.

The antenna and power jack are mounted on the circuit board and Molex connectors are used for all other attachments. The terminals are made to be crimped onto wire. Few amateurs have access to a proper

crimping tool and pliers make a poor job. Form the terminals into a cylinder around the shank of a small drill and solder the leads. To remove a terminal, hold the housing in a vise and extract it with a pointed Xacto blade. It takes a little practice and terminals can be re-cycled several times. Use thin stranded hook-up wire or ribbon cable.

Test equipment does not have to be elaborate. If you do not have an oscilloscope you can make a simple RF probe to use with a multimeter; if you do not have a frequency counter you can get by using a calibrated receiver; if you do not have an audio signal generator you can whistle and groan into the microphone (don't overdo this or your family become concerned about you); if you do not have a spectrum analyzer you can have the amateur next door check your signal quality.

· Mount the circuit board on the temporary chassis. It is assumed that you have already made up a fused power lead and carried out the DC voltage checks described on p. 5. Do not install jumpers at J3 & 4.

· Connect the "wiper" terminal of the tuning pot R24 to pin 6 of CON2. Connect the "bottom" end of R24 to ground (or chassis) via a 4k7 resistor (not provided). Connect the "top" end R24 to pin 3 of CON2. The connections are usually shown on the pot but easy to determine with an ohmmeter. Verify that the DC voltage on the wiper terminal varies from c. +3V to +8Vas R24 is tuned. Leave this set to c. 5V

· With an RF probe verify that both oscillators are functioning. Set the LF oscillator to 452.6KHz with the trimmer cap. Tune for the 9th harmonic at 4.074MHz on a closely coupled receiver . Most amateur band receivers tune 100KHz beyond the band edge.

· Adjust L6 until the VFO frequency (measured at pin 4 of CON2) is approximately 4.2MHz. To avoid having the slug protrude screw it deep into the can and tune upwards (anti-clockwise) to lower the frequency.

· Now install the mixers U2 & 3, and the switch U6 in their sockets. With an RF probe verify that pin 6 on each shows a reading of at least 140mV RMS. These reading are unlikely to be identical. Close the relay by grounding pin 1 of CON1 and the readings should then "switch" indicating that U6 is functioning. A counter will, of course, display the frequency change.

· Install the audio amplifier U5 and connect an 8 ohm speaker between pins 1 & 2 of CON2. Touching pin 1 or pin 2 of U5 with your finger should produce a loud hum in the speaker.

· Connect an 80M antenna at J1 (the receiver is quite sensitive but will not function using a non-resonant piece of wire). Advance the RF gain pot R22 fully clockwise, tune across the band to find a SSB station and tune L5. Install D5 to establish that the AGC circuit is functioning. **Do not commence testing and aligning the transmitter until you are first satisfied that the receiver is functioning properly.**

· Connect an electret microphone element (2-lead type) to pins 2 & 3 of CON1. For testing this may be mounted directly into the terminal housing or through a piece of screened cable. Pin 3 is the ground. At the same

time install a wire to pin 1 for closing the relay. You can add push-button switch or just ground the wire to the chassis for testing.

· Install the pre-amplifier U4. Place a probe on pin 4 of the 2nd mixer U3 to act as a radiator, PTT (close the relay) and speak into the microphone. Monitor the signal on a receiver using headphones. Any problem at this stage is most likely to be in the speech amplifier or microphone since the mixers and oscillators function in the receive mode.

· Set R20 (RF drive) to minimum. This will be fully clockwise if R20 is oriented as shown in the parts layout. Bear in mind that multi-turn trimpots do not have end stops. Install a milliammeter at J4. (use the 2-pin Molex housing supplied for attaching a frequency display and make up a cable). Close the relay and verify that the standing current in the driver U1 is c. 25mA. Open R20 three or four turns, speak into the microphone while monitoring the signal on a receiver using headphones. No radiator should be required.

· Replace the meter with a shorting jumper at J4. PTT and measure the voltage at the gate pad of (yet to be installed) Q1. This is the right-hand pad nearest the driver. Adjust R19 to set this to c. 3.0V. Verify that this drops to zero when the PTT is released. Remove the jumper from J4 and install it on J3. Verify that the drain (center) pad for Q1 reads +12V.

· **Refer to the Diag. D and install Q1. From now on you must make sure that the circuit board is fully grounded to the chassis at all five mounting points.**

· Install a 50 ohm dummy load at J1 and LED D7 at CON4.

· Remove the jumper from J4 (driver current) and install a milliammeter at J3 (PA current). PTT and adjust R19 to set the idling current to 45mA.

· Re-install the jumper at J4, PTT, and modulate with a level tone. The current at J3 will increase and D7 will light. Now tune both sections of the bandpass filter L3 & L4 for maximum current. Do not "stagger tune" the coils. Adjust R20 so that the current at J3 does not exceed 900mA on peaks with normal speech. Verify that the current rapidly drops to the idling level with no modulation.

· Re-check the driver current at J3. Similarly, this should rise to 60 - 70mA with modulation and drop to 25mA.

· You are now ready to go! Connect the antenna and have another amateur check your signal.

**Frequency display:** Several designs were published for LED digital frequency displays for the EP-2. These generated a lot of noise and consumed a lot of current. Today there are several DFD kits available with LCD displays, programmable offsets and none of these disadvantages. K1MG's (Blue Sky Engineering Co.) Digital Clock/ Counter is perhaps least expensive, simplest to build and install.

**Enclosure:** There is nothing to prevent you operating from the test chas-

sis but sooner or later you will want to install it in a professional-looking package. The Ten-Tec TG-26 enclosure should accommodate the EP-3 circuit board and a K1MG DFD nicely. I believe this was used by W6MMA to house the prototype he assembled. The low-profile circuit board is also ideal for installation in a "slim-line" enclosure with the display on top and thumb-wheel tuning.

**Bandspread:** The 4k7 ohm resistor from the 10-turn tuning to ground serves to prevent the voltage at tuning diode dropping to zero. Below one volt it becomes very unstable. So long as this limitation is observed it's value may be changed to set the band spread.

**Frequency stability:** The VFO frequency drops c. 400Hz during the first five minutes after switching on from cold. So long as the temperature within the enclosure remains constant it is quite stable. If you are transmitting for long periods on a net frequency, occasional adjustments are necessary. To compensate for this you can play with the values of C33 and C33A (which have differing thermal charactistics) and install a diode in series with the tuning pot, or make your next project a "huff and puff"!

**Microphone:** The simplest and most foolproof is an electret mic in which the PTT switch directly grounds the relay coil. If the switch is in the mic lead itself (as is the case with most spkr/mics) you will have to install a transistor to switch the relay. If you use a dynamic mic remove the bias resistor R13.

**EPIPHYTE 3 PARTS LIST**

**CAPACITORS**

| No. | Cap | Type | Source | Stock No. |
|---|---|---|---|---|
| 1 | 470uF | elect/16V | MOUSER | 140-XRL16V470 |
| 3 | 100uF | elect/50V | MOUSER | 140-XRL50V100 |
| 2 | 10uF | tant/25V | MOUSER | 74-199D25V10 |
| 6 | 1uF | tant/35V | MOUSER | 74-199D35V1.0 |
| 1 | 1uF | cer/50V | DIGI-KEY | P4968-ND |
| 14 | 100nF | cer/50V | DIGI-KEY | 1210PHCT-ND |
| 5 | 10nF | cer/50V | DIGI-KEY | 1103PHCT-ND |
| 1 | 4700pF | cer/50V | DIGI-KEY | 1102PHCT-ND |
| 1 | 1200pF | polystyrene | MOUSER | 23PS212 |
| 3 | 2200pF | cer/50V | DIGI-KEY | 119PHCT-ND |
| 5 | 1000pF | cer/100V | DIGI-KEY | 116PHCT-ND |
| 5 | 680pF | cer/100V | DIGI-KEY | 1114PHCT-ND |
| 2 | 680pF | cer/50V | DIGI-KEY | 1009PHCT-ND |
| 6 | 470pF | cer/50V | DIGI-KEY | 1007PHCT-ND |
| 2 | 270pF | cer/100V | DIGI-KEY | 1111PHCT-ND |
| 1 | 100pF | cer/50V | DIGI-KEY | 1001PHCT-ND |

| | | | | |
|---|---|---|---|---|
| 1 | 47pF | cer/100V | DIGI-KEY | 1017PHCT-ND |
| 4 | 33pF | cer/100V | DIGI-KEY | 1016PHCT-ND |
| 2 | 15pF | cer/100V | DIGI-KEY | 1012PHCT-ND |
| 1 | 5 - 65pF | trim cap | DIGI-KEY | SG3009-ND |

**RESISTORS** (All Resistors 0.25W & vertically mounted unless otherwise specified)

| | | |
|---|---|---|
| 2 | 100k | |
| 1 | 47K | |
| 1 | 15k | |
| 4 | 10K | |
| 3 | 4k7 | |
| 2 | 2k2 | |
| 1 | 1k5 | |
| 1 | 1k | |
| 1 | 470 | |
| 1 | 330 | |
| 1 | 100 | |
| 2 | 47 | |
| 1 | 10 | |
| 1 | 10k | 3/8" multi-turn square Cermet trimpot 0.1" in-line pin sp. |
| 1 | 100 | Multi-turn carbon trimpot 0.1" in-line pin sp. |
| 1 | 2k5 | PHIER Trimpot extension shaft |
| 1 | 10k | 10-turn precision tuning pot |

**INDUCTORS**

| | | |
|---|---|---|
| L1,L2 | 1.68uH | Iron powder core 20/T #24g enam T-37-2 |
| L3,4,5 | 4.7uH | TOKO tunable coil 154AN-T1005 TK1203-ND |
| L6 | 3.3uH | TOKO tunable coil BTKANS9445 DIGI-KEYTK1414-ND |
| L7,8,9 | 1000uH | Molded choke MOUSER 43HH103 |
| L10 | 40uH | Ferrite Bead 12-turns #24g enam FB-43-2401 |
| L11 | 1000mH | Epoxy Coated Choke Low Res (12 ohms) MOUSER 43LS103 |

**TRANSFORMERS**

T1 RF Trans Ferrite Bead 5 trifilar t. #26g enam FB-43-2401
T3 Prim. 1 t. #24g enam Sec. see text FB-43-2401
T2 RF Transf Binocular Prim. 2 t. #24g enam Sec. 5 t. #26g enam BN-75-202

**CONNECTORS**

J1 PCB Mount BNC
J2 PCB Mount DC Power Jack
J3,4 2 Pin Header & Jumper

**IC's, DIODES & TRANSISTORS**

Q1 IRF510
Q2 MPF102
Q3 MPF102
Q4 MPF102
U1 CA3020 or CA3020A
U2 NE602, NE612, SA602, SA612
U3 NE602, NE612, SA602, SA612
U4 LM741
U5 LM386-4
U6 MC4066
U7 78L08
U8 78L09
D1 1N914
D2 1N914
D3 1N914
D4 MVAM108, 1SV149
D5 Red or Green LED, High Eff. 2.1Vf
D6 1N4005
D7 Red or Green LED

**MISC.**

F1 MuRata M455J1 Ceramic SSB Filter
X1 455 kHz Ceramic Resonator
K1 Miniature 12V DPDT Relay
SW1 PCB Mount SPDT Switch
4 8 pin IC Sockets (Optional)
1 14 pin IC Socket (Optional)
1 TO220 Thermal Mounting Kit
1 Nylon Bushing
1 1/4 x 4-40 Machine Screw and Nut
4 PCB Standoffs, 1/4" x 4-40

# SMK-1 ROCK-BOUND NO MORE

by Wayne McFee NB6M

I have had so much fun with the little SMK-1 that I couldn't help thinking how much more fun I might have with it if only it had a VFO. I thought "why not?" So, I got started thinking about what all I would have to change or add in order to couple a VFO to the receiver and transmitter circuits in the SMK-1.

## INITIAL PLANNING

First of all, I would have to remove both VXO crystals and their associated circuitry. Then, I would have to modify the transmitter's oscillator circuit so that it would act as an amplifier instead of as an oscillator. Not only would I need to build a stable VFO, with sufficient tuning range to cover most of the CW portion of the band, I would need to provide for transmitter frequency offset, and, since the receiver would no longer have its own LO, a means for providing sidetone would have to be added to the rig.

After a little thought, and some experimental work, the result is a very nice VFO, with RIT and transmitter frequency offset a la Roy Lewallen, W7EL, a tuning range of from just below 7.000 MHz to 7.115 MHz, NO expensive tuning capacitors or even tuning diodes to buy, and only one tuning coil and two toroids to wind. The rest of the VFO, including the RIT circuit, is all built with cheap, easy to come by (Radio Shack) parts.

In perusing the Internet for any and all QRP related info, I had seen a circuit on WA6OTP's website for a Permeability Tuned Oscillator which used a small diameter, air wound coil, with a 6-32 brass screw threaded into the center, as a tuning element. That got me really excited. That tuning element was just what I was looking for. The tuning coil was small, would cost almost nothing to make, and would provide not only the inherent stability of an air-wound coil, but, with the brass tuning screw, would provide plenty of tuning range. Also, with the use of brass as the varying element, the VFO frequency would increase, as the tuning knob was turned clockwise, just like radios "normally" tune. Nice.

As it turns out, at the low end of the tuning range, one full turn of the tuning knob moves the VFO output about 8 KHz. At the upper end of the tuning range, one full turn of the tuning knob moves the VFO output about 13 KHz. Not quite linear, but not bad at all.

Considering the fact that I wanted to eventually be able to build the VFO right inside the small confines of my SMK-1 case, which puts space at a premium and almost precludes adding a lot of shielding around the VFO oscillator, I wanted to put the VFO on 3.5 MHz and employ a frequency doubler circuit in order to arrive at 7 MHz. This would minimize any inter-action between the transmitter signal and the VFO, preventing

any pulling or chirping.

Since removing the VXO circuitry for both the receiver and transmitter would mean that I now had a couple of spare 10K pots, I thought why not remove the Receiver's VXO pot completely and use that position as the eventual location for the tuning coil, and why not use the Transmitter's old VXO pot as an RIT control, since by providing an RIT circuit, a la W7EL, I would not only have transmitter offset but would enjoy RIT as well.

The RIT circuit, with the values used, provides about 1.5 KHz of tuning range. Just about right for a 600 to 800 cycle tone with the RIT control centered in its range and with the transmitter tuned for zero beat on an incoming signal. The "Spot" switch makes tuning signals really easy. Simply hold the Spot switch in, tune the VFO for zero beat on the incoming signal, release the Spot switch, and adjust the RIT control for the desired tone pitch.

As for providing sidetone, a couple of routes came to mind. A sidetone oscillator circuit could be built in, but since I really like and enjoy the little Tick Keyers, I thought why not put in a Tick chip and keying transistor, and run the audio from the Tick to the audio chain as sidetone. This route has been used successfully in several rigs, including the Tixie, and works very well. The choice is yours.

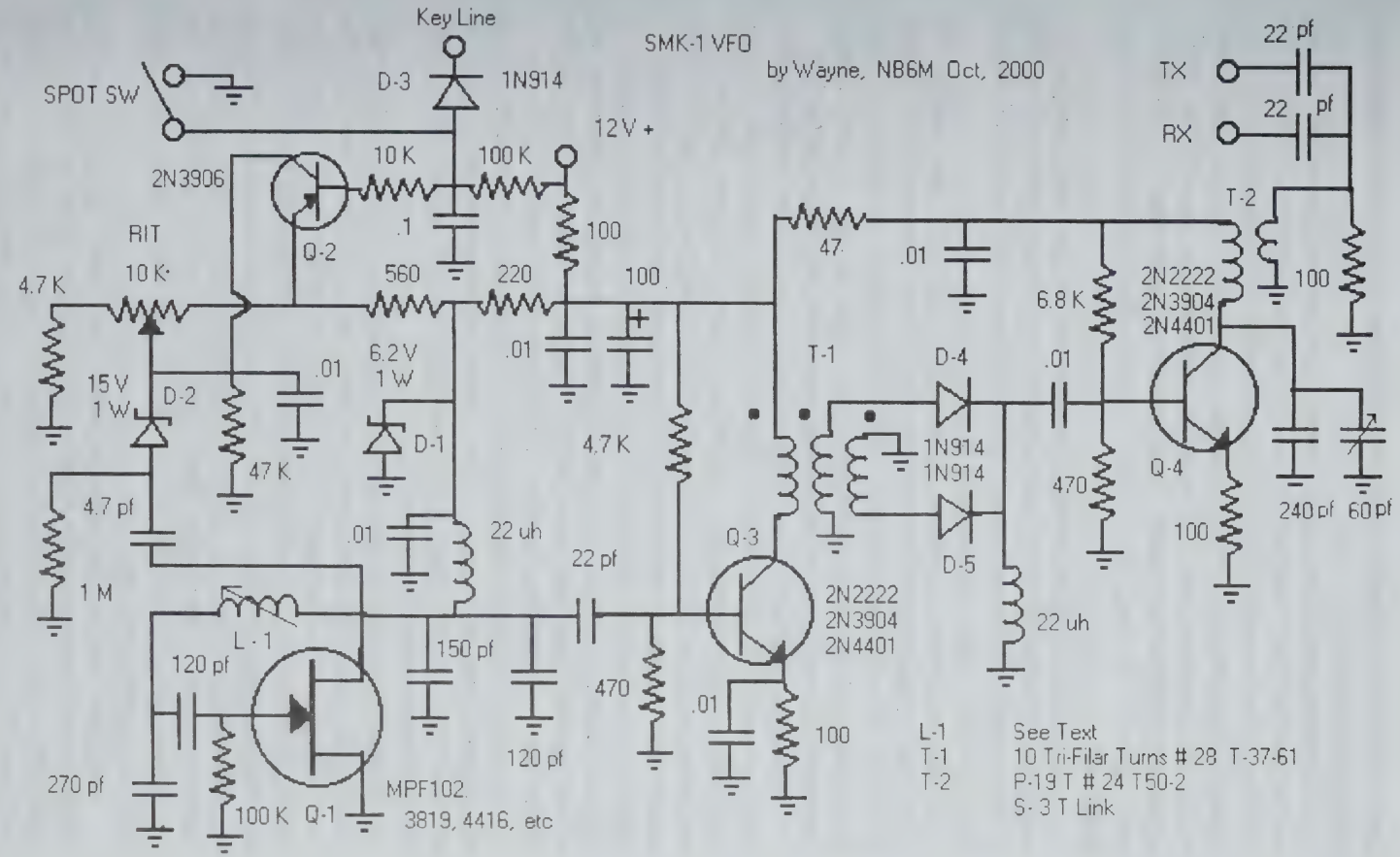
**BUILDING THE VFO**

Now that I had a plan, the work could begin. As a very fitting start, at a NorCal meeting at California Burger, in Pleasanton, I kept the drinking straw from my soft drink to use as my coil form. It was a nice, substantial one of 5/16" diameter. WA6OTP had used old potentiometer housings as a building platform for his coils, but I elected to do it an even easier way. Using an electric grinder, I rounded the corners off a brass 6-32 nut, rounding it to a size that the drinking straw would just fit over.

Then, after drilling a clearance hole in the front panel of the VFO, which is double sided PC board, I threaded the rounded nut onto a brass 6-32 screw, set the screw in the hole, with the rounded nut on the inside surface of the front panel, and soldered the rounded brass nut to the inside surface.

Then, threading a new 6-32 brass nut onto the screw on the outside of the front panel, I tightened it down just enough to provide added thread support, but not tight enough to prevent easy turning of the tuning screw. Once that was done, I soldered the outside brass nut to the surface of the front panel.

While allowing the assembly to cool, I used a sewing needle to poke small holes close to one end of the drinking straw in order to anchor the end of the # 30 magnet wire used in the tuning coil, and wound 95 turns, close-wound, onto the 5/16" diameter drinking straw. Although the coil needs about three less turns than that in its final version, the extra turns provide plenty of room for error. It is quite easy, after the entire VFO


Key Line
SMK-1 VFO
by Wayne, NB6M Oct, 2000
SPOT SW
D-3
1N914
12 V +
22 pf
TX
22 pf
RX
2N3906
10 K
100 K
.1
100
Q-2
RIT
10 K
4.7 K
560
220
100
47
.01
T-2
2N2222
2N3904
2N4401
6.8 K
100
15 V
1 W
D-2
.01
6.2 V
1 W
D-1
.01
4.7 K
T-1
D-4
1N914
1N914
D-5
Q-4
470
240 pf
60 pf
100
47 K
4.7 pf
.01
22 uh
22 pf
Q-3
2N2222
2N3904
2N4401
1 M
L - 1
120 pf
150 pf
470
.01
100
22 uh
120 pf
270 pf
100 K
Q-1
MPF102
3819, 4416, etc
L-1 See Text
T-1 10 Tri-Filar Turns # 28 T-37-61
T-2 P-19 T # 24 T50-2
S- 3 T Link

circuit is finished, to remove coils one at a time to make the needed frequency adjustment.

The sewing needle was again used to poke small holes in the straw, next to the last turn, to anchor the end of the coil in place. The coil form (drinking straw) is easily trimmed, close to the anchored last turn, with scissors. Once the coil form is trimmed, use 5 minute epoxy to fasten one end of the coil form over the rounded brass nut, up against the inside surface of the VFO front panel. Use the tuning screw itself, a 6-32 brass screw about 1 ¼" long, as a guide to ensure that you have the coil on straight.

The head is cut off the screw to facilitate installing a small tuning knob, and mine ended up being just over an inch long, including the portion that is inside the knob. Leave yours 1 ¼" long to begin with, and cut it as you like to give the upper frequency limit you wish.

In my experimental version, all the VFO, RIT and Keyer stages are built "Ugly" style, in the manner of Wes and Roger Hayward, W7ZOI and KA7EXM. The final version, which will be installed in my SMK-1 with the 5 Watt Mod, will probably be done in "Ugly" style as well, but with a great deal more thought given to parts placement and circuit miniaturization.

Since this VFO would do very well as a stand-alone module which could be used with your choice of QRP rig, I would suggest that you give some thought to building your version in a case of its own, particularly if you have put your SMK-1 into a minimally sized case. The VFO box would need to be supplied with 12 Volts (or could be battery supplied). A wire would be needed from the VFO to the rig's keying line to provide for RIT (and transmitter frequency offset) disabling during transmissions, and a small coaxial cable would run the VFO output to the rig. As long as the rig had it's own sidetone, no more cabling would be needed.

The two 22 pf caps shown on the VFO output would be installed inside the rig itself, one at the input of the transmitter amplifier and one at the receiver mixer. In that fashion, only a single VFO RF Output cable would be needed to connect to the rig.

In order to make the building process easier, I have provided additional circuit diagrams that break the main circuit diagram down into four parts, detailing the Oscillator, RIT circuit, First Buffer Amplifier and Frequency Doubler, and Tuned Buffer Amplifier. I have separated the parts list into four sections in the same manner, so that you can gather the parts for each stage individually. The building style is up to you. "Ugly Style" works very well. "Manhattan Style" would also be a good choice. You could even design a printed circuit board, if you wish. Mine is built "Ugly Style" and works very well.

I suggest that you build the oscillator circuit first. DO NOT coat the entire coil with epoxy or other fixative yet, as a few turns will have to be taken off in order to fine-tune the frequency range. Be mindful of the fact that the 4.7 K biasing resistor, the top lead of the primary of T-1 and the 47

Ohm resistor for the voltage supply to the Tuned Buffer Amp will all have to attach to the junction of the 100 Ohm resistor, 220 Ohm resistor, .01 Cap and 100 UF Cap, so plan accordingly in your layout. Also, NOTE that all the small value capacitors (values in pf) are NP0, Poly, or Silver Mica. Good chance to use some of those NorCal capacitors, hi.

Once the oscillator is built, apply 12 Volts and check for oscillation by listening for the output in a general coverage receiver, or by measuring the RF level at the Drain of the MPF-102 (about 3-4 volts RMS), or by looking at the waveform with an oscilloscope.

You will probably have to listen well below the 3.5 MHz Fundamental Frequency initially. At this point we are just checking for oscillation, so don't make any frequency adjustments to the coil until after the amplifier and frequency doubler stages are all completed, as the loading effect of these stages will affect the frequency of the oscillator.

Once you have confirmed oscillation, build the next portion, the RIT circuitry. The RIT disabling transistor, Q-2, and its associated parts can be mounted on the RIT pot itself, if desired, which helps make for a neater installation. Also, you may want to hook up the RIT pot only temporarily at first, to ensure that you get the correct rotation. You want the RIT pot to tune the same direction as the main tuning knob, up in frequency with clockwise movement.

The "Spot" Switch, a "Normally Open" push-button type switch, is mounted in a convenient spot on the front panel of the VFO. Test both the frequency offset function, by pushing the Spot Switch, and the RIT function, by turning the RIT control and listening to the output in your general coverage receiver. Remember that when you are listening to the 3.5 MHz fundamental frequency, the tuning range will only be about 750 Hz.

Once the RIT section is completed and tested, build the First Buffer Amplifier and Frequency Doubler. T-1 is a tri-filar winding of # 26 or # 28 magnet wire on a T37-61 core. Be sure to observe correct polarity when making its connections to Q-3 and the frequency doubler diodes.

Also, it will be important to measure the forward resistance of the diodes used, selecting two with the closest resistance measurements so as to balance the doubler, which will help ensure that the lowest amount of fundamental frequency energy possible will be felt at the VFO output.

If you have an oscilloscope, you can look at the waveform on both the input of the First Buffer Amplifier and the output of the Frequency Doubler to check their function. Alternatively, measure the RF output on the Collector of the First Buffer Amplifier, and then again on the output of the Frequency Doubler.

On mine, the approximate RF voltage readings are as follows:

| | |
|---|---|
| Drain of Oscillator | 4 Volts RMS |
| Base of First Buffer Amp | .8 Volts RMS |
| Collector of First Buffer Amp | 2.2 Volts RMS |
| Output of Frequency Doubler | .48 Volts RMS |

When the First Buffer Amplifier and Frequency Doubler section is finished and tested, build the Tuned Buffer Amplifier section. T-2 has a primary of 19 turns # 24 on a T50-2. The secondary is a 3-turn link spread over the center area of the primary.

A T37-2 could probably be used, to reduce the size, but a few more turns will be needed. A 21-turn primary would be a good start, but the 240 pf capacitor might have to be changed to 220 pf to get it to resonate. Remember that the 240 pf cap is either a NP0, Poly, or Silver Mica.

When the Tuned Buffer Amplifier section is built, now is the time to make frequency adjustments to the tuning coil. Hook an RF probe onto the top of the 3-turn link on T-2 and adjust the trimmer to see if the circuit will resonate at the second harmonic of the oscillator frequency, adjusting for highest output.

Alternatively, you can listen for the second harmonic on your general coverage receiver and adjust the trimmer for loudest signal. Although mine resonated both at the second harmonic of 6.880 MHz initially, and at the final second harmonic of 7.050, don't be too upset at this point if your trimmer won't bring the tuned amp to resonance at your initial, lower second harmonic. Just adjust for the most output you can get at this point.

To make the frequency range adjustment on the tuning coil, start by removing the tuning screw completely. This will ensure that you are at the lowest frequency possible to tune. Remove supply voltage from the circuit. Then, remove one turn from the coil, trim, scrape and tin the wire, and re-solder it into the circuit.

Use your general coverage receiver, or a frequency counter if you have one, to check the new low-frequency end of the tuning range. NOTE how much the frequency changed when one turn was removed from the coil. If you want full coverage of the low end of the band, as I did, once you get the new low-end frequency within 20 KHz of 7.000 MHz, that is probably close enough.

However, it is your responsibility to ensure that you don't transmit outside the band. The safest way would be to set the low frequency limit up just above 7.000 MHz, removing one turn at a time until you have the frequency set. Once the coil is adjusted for a low frequency limit inside the band, small amounts of capacitance (2 pf, for example) can be added from the Drain of the oscillator to ground to make fine adjustments downward, if needed.

My first version tunes from about 6.990 to 7.115 MHz, with a screw just over an inch long. I could increase the upper limit by using a slightly longer screw, perhaps 1 ¼", which probably would get me up past 7.150 MHz.

Remember, it is much more difficult to add turns, once they are cut off, so if the lower frequency is close, and you have tuning range to suit you, leave well enough alone. However, if you do make a mistake and cut one or two turns too many, don't despair. Simply add a small amount of ca-

pacitance, say 2 pf, 4.7 pf, 10 pf, or 12 pf, NP0, from the Drain of the oscillator to ground, and that will bring the frequency back down.

Now that the oscillator is on the right frequency range, coat the winding of the tuning coil to fix the turns solidly in place. This is very necessary, in order to provide the best stability from the oscillator and VFO output. I used 5-minute epoxy, and coated the entire surface of the winding.

Also, now that the VFO output is in the right frequency range, the trimmer on the output of the Tuned Buffer Amplifier will have to be readjusted. Tune the VFO to the center of your tuning range, and either use an RF probe or an oscilloscope to monitor the adjustment of the trimmer. Trim for best output and/or the cleanest waveform. The RF voltage reading at the top of the 3-turn secondary of T-2 is approximately .78 Volts RMS.

During my initial on-the-air trials of the VFO and SMK-1 combination, just to double check, I had a nearby ham listen for the fundamental frequency while I transmitted, and received a clean, nothing heard, report. Should you end up with too much fundamental frequency in your VFO output, it would indicate that the Frequency Doubler diodes were not matched initially, or could have been overheated when being installed, which resulted in their forward resistance characteristics changing.

**MODIFICATIONS AND CABLING TO SMK-1**

Dual soldering irons are a must for this project. With those, the most interesting part of the exercise will be removing the removed part from whichever iron it sticks to. I recommend a damp pad of cloth to wipe the part off on.

As indicated, I removed both VXO crystals and their associated circuitry from the SMK board. This included X-1, VR-2, C-15, R-2, L-3, C-4, C-5, R-3, D-3 and D-4 in the receiver, and X-2, R-7, D-6, D-7, and C-16 in the transmitter. All the parts are taped down to a sheet of paper, and their values written next to them, one at a time as they are removed. Then the parts, with their identifying info, are appropriately filed away for later use.

If you have enough room to build the VFO inside your SMK case, cut the PC Board 12 Volt trace that goes to the VR-3 connection closest to the right hand edge of the board, cut the opposite, left hand VR-3 contact itself that goes to ground and unsolder and remove the cut off portion of the VR-3 contact.

The 12 volt trace going to the + side of VR-3 is cut just about even with the ground end of D-3. That leaves 12 volts going to the pad for C-15, which will allow us to pick up 12 volts for the base circuit of the 2N3906 RIT disabling transistor there, and will keep the trace going from the + side of VR-3 to the + side of VR-2's connections going, so that we can put the 680 resistor for the RIT pot there, and run a wire from the 6 Volt side of C-6 to the R-2 pad closest to X-1's location in order to supply the RIT circuit with 6 Volts regulated.

The 4.7 K Ohm resistor in the RIT circuit is run from the cut off contact on the VR-2 side of VR-3 to ground. The 2N3906 is soldered directly to the wiper and 6 Volt contact of VR-3, with the emitter going to the 6-volt contact and the collector going to the wiper. A wire also connects to the wiper to run to the junction of the 47 K Ohm resistor, .01 cap and the cathode of the 15 Volt Zener, which are all located on the oscillator board, close to the Drain of the MPF102. The 100 K Ohm resistor in the base circuit of the 2N3906 runs from the + pad of C-15's location straight up, and the 10 K Ohm resistor connects to the top of the 10 K resistor and goes to the base of the 2N3906. The .01 cap is connected at the junction of the 10 K and 100 K resistors, and goes to the ground pad for D-4.

The 1N914 goes from the junction of the 10 K, 100 K and .01 to the key line side of R-16, with the cathode towards R-16. The spot switch is connected from the junction of the 10 K, 100 K, .01 and 1N914 to ground and is located in a convenient spot on the front panel.

That places all the RIT control and switching circuitry on the SMK board, at or near VR-3's location, leaving fewer components on the VFO board. The main VFO board could then be integrated into the top and left side of the SMK case, leaving the right side for the 1 Watt or 5 Watt Mods, if desired, or could be stacked below the main SMK board, with the VFO board near the SMK board and the components of the VFO board facing away from the SMK board and the tuning screw protruding through the front of the case.

If you are going to build the VFO as an outboard item, VR-3 is removed. An easy way to remove VR-2 and VR-3 is to cut their contacts at the top surface of the SMK-1 PC Board. This still leaves enough contact remaining to solder to and use one of them as an RIT control.

If you are planning on making your VFO an outboard item, the two 22 pf caps shown on the output of the VFO are installed on the SMK-1 board. With all the VXO related parts removed from the board, the two 22 pf caps can go quite nicely in the X-1 and C-16 locations. A wire soldered to the L-3 pad closest to the X-1 location, the R-7 pad closest to Q-2, and running to a jack on the back of the rig, for VFO input, would then complete the VFO-to-Rig RF connection inside the SMK-1.

In order to change the transmitter oscillator on the SMK-I board into an amplifier, you will need to remove R-8 and C-18 from the circuit. Then, move R-9, the 4.7 K Ohm resistor, to R-8's old position (changing R-8's value from 47 K to 4.7 K) and install a leaded 1500 Ohm resistor in R-9's place.

How you provide for a keying line for the Frequency Offset/RIT circuit will depend on whether you choose to build a keyer into your rig or not. If you do, then you will have to provide a jack and cable for that line to the VFO. If you use an outboard keyer and an internal sidetone oscillator, one way to provide the keying line to the VFO would be to use a one plug to two jack adaptor in the key jack on the back of the rig, and plug both the keyer

and the key line from the VFO into that. Those decisions are for you to make.

Also, if you elect to install a Tick Keyer in order to provide sidetone (not to mention the benefits of a keyer, apply the audio, using the circuit components described in the Tick circuit diagram provided with the chip, to the input of U-2 at pin 3, and make resistor value adjustments as necessary to adjust the sidetone level to your liking.

**FINAL THOUGHTS**

Yes, I know this project is a bit more complicated than adding the 5 Watt Mod to the SMK-1. However, it is a very worthwhile project that can be used with a variety of small, formerly rock-bound, QRP rigs, and, taken in stages, is not difficult at all to build. Just imagine being able to tune the whole CW portion of the band, with RIT thrown in for good measure. And, with a 1.5" long tuning screw, the VFO will tune the entire 40 Meter band, allowing you to listen to your favorite 40 Meter SSB activity as well as doing your regular CW operation on the lower part of the band.

I have worked Japan and other far away places on the low end of 40 Meters with one watt out of other QRP rigs, at sunrise in the morning, and I am eager to try it with my VFO-controlled SMK-1 with its stock 300 MW output.

Should you wish to use the VFO for another band, the oscillator, with the 120 pf cap removed, and with the number of coil turns adjusted downward appropriately, is quite stable certainly up past a 7 MHz fundamental frequency, which would give you 30 and 20 meter capability. I suspect that, with care, it might even be stable enough for a 10.5 or 14 MHz fundamental, which would provide for operation through 10 Meters. It would certainly be worth experimenting with.

Enjoy,
Wayne NB6M

**PARTS LIST**

**OSCILLATOR**

| | |
|---|---|
| Q-1 | MPF102, 2N3829, 2N4416, etc |
| D-1 | 6.2 V, 1 W Zener |

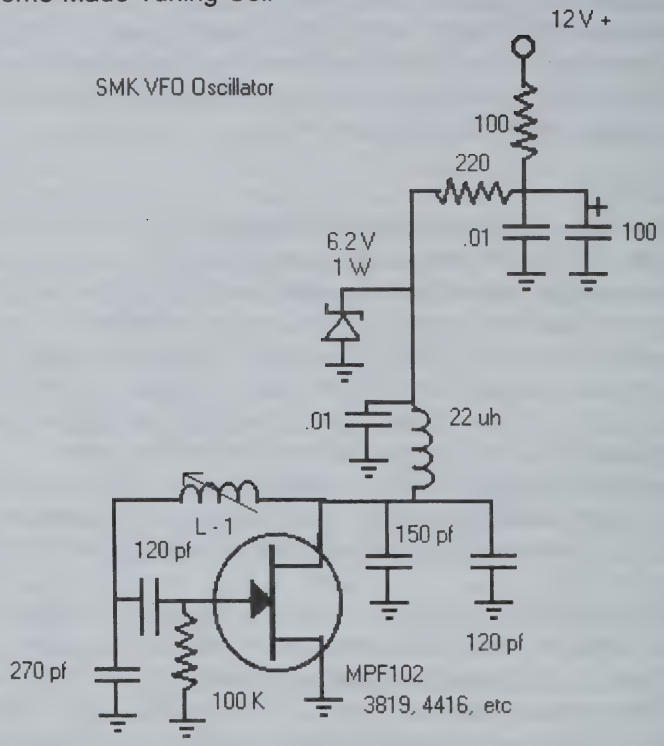
**Resistors**

1 100 Ohm
1 220 Ohm
1 100 K Ohm

**Capacitors**

1 270 pf NP0
2 120 pf NP0
1 150 pf NP0
2 .01 Disc Ceramic
1 100 UF 16 Volt Electrolytic

Inductors
1 22 uh RF Choke
1 Home-Made Tuning Coil

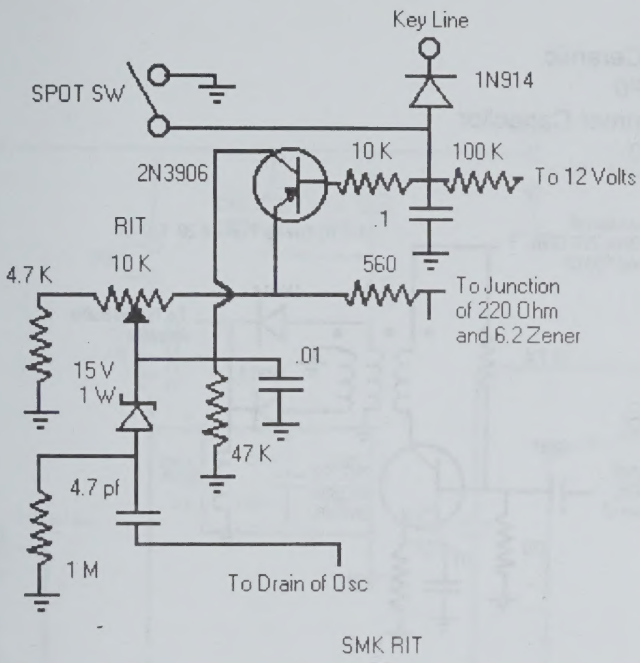



**RIT CIRCUIT**

| | | |
|---|---|---|
| 1 | Q-2 | 2N3906 |
| 1 | D-2 | 15 V, 1 W Zener |
| 1 | D-3 | 1N914, 1N4148, etc |
| 1 | SW-1 | NO miniature push-button |
| 1 | RIT Control | 10K Linear Pot |

**Resistors**
1 100 K Ohm
1 10 K Ohm
1 560 Ohm
1 4.7 K Ohm
1 1 M Ohm
1 47 K Ohm

**Capacitors**
1 .1 Disc Ceramic
1 .01 Disc Ceramic
1 4.7 pf NP0




**FIRST BUFFER AMPLIFIER AND FREQUENCY DOUBLER**

| | | |
|---|---|---|
| 1 | Q-3 | 2N2222, 2N3904, 2N4401, etc |
| 2 | D-4, D-5 | 1N914, 1N4148, etc |
| 1 | T-1 | 10 Tri-Filar Turns # 26 or # 28 on T37-61 |

**Resistors**

1 4.7 K Ohm
1 470 Ohm
1 100 Ohm

Capacitors

1 22 pf NP0
1 .01 Disc Ceramic

Inductors

1 22 uh RF Choke

**TUNED BUFFER AMPLIFIER**

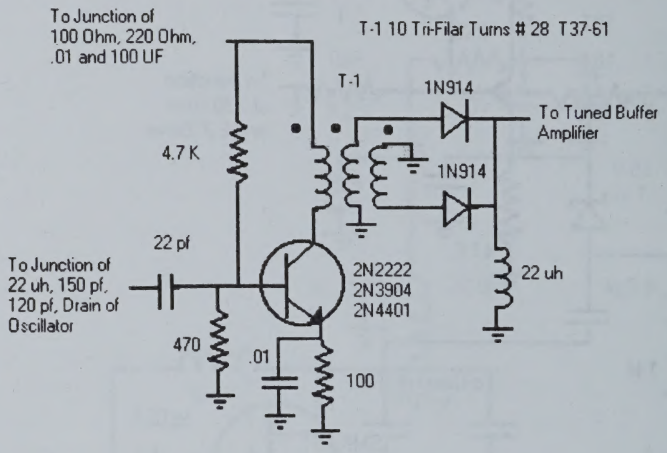
| | | |
|---|---|---|
| 1 | Q-4 | 2N2222, 2N3904, 2N4401, etc |
| 1 | T-2 | Primary, 19 Turns # 24 on T50-2 Secondary, 3 Turn Link, spread on Center of Primary |

**Resistors**

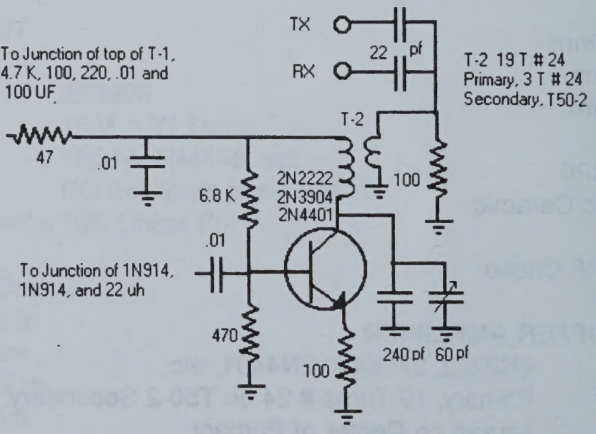
1 47 Ohm
1 6.8 K Ohm
1 470 Ohm
2 100 Ohm

**Capacitors**

2 .01 Disc Ceramic
1 240 pf NP0
1 60 pf Trimmer Capacitor
2 22 pf NP0




SMK VFO First Buffer Amplifer
and Frequency Doubler




SMK VFO Tuned Buffer Amplifier

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